GUIDANCE FOR CONDUCTING REMEDIAL INVESTIGATIONS AND FEASIBILITY STUDIES UNDER CERCLA

Office of Emergency and
Remedial Response

Office of Solid Waste and
Emergency Response

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GUIDANCE FOR CONDUCTING REMEDIAL INVESTIGATIONS AND FEASIBILITY STUDIES UNDER CERCLA

This guidance was produced to assist Regional and State remedial personnel, contractors and other parties involved in conducting remedial investigations and feasibility studies and is reflective, to the extent possible, of the revisions currently being made to the National Contingency Plan (NCP). This guidance, however, does not currently address procedures for non-final remedial actions, which are part of the current revisions to the NCP. Guidance for initiating non-final actions will be addressed through a separate guidance or will be incorporated into the forthcoming revisions to this guidance.

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CHAPTER 1
INTRODUCTION

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WDR260/005

GLOSSARY

ARAR - applicable or relevant and appropriate requirements

ATSDR - Agency for Toxic Substance and Disease Registry: A branch of the Centers for Disease Control that is responsible for preparing health assessments at sites.

Bench scale - Treatability tests performed on a small scale, usually in a laboratory, to better define parameters of a treatment technology.

CAA - Clean Air Act

CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act of 1980, also known as Superfund: Amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA).

CLP - Contract Laboratory Program

CRL - central regional laboratory

CRP - community relations plan

CWA - Clean Water Act

DQO - data quality objectives: Statements that specify the data needed to support decisions regarding remedial response activities.

EMSL - environmental monitoring support laboratory

ERA - expedited response action

Excess lifetime cancer risk - The potential for carcinogenic effects from exposure to one or more chemicals.

FIT - field investigation team

FS - feasibility study

FSP - field sampling plan: Defines in detail the sampling and data gathering activities to be used at a site. (See SAP.)

General response action - General types of actions, such as containment, that may be taken to achieve exposure limits specified by remedial action objectives.

Health assessment - Assessment of existing risk to human health posed by NPL sites, prepared by the ATSDR.

Innovative technologies - Technologies that are fully developed but lack sufficient cost or performance data for routine use at CERCLA sites.

Lead agency - The agency, either the EPA, Federal agency, or appropriate State agency having primary responsibility and authority for planning and executing the remediation at a site.

MCL - maximum contaminant level: Established under the Safe Drinking Water Act.

MCLG - maximum contaminant level goal: Established under the Safe Drinking Water Act.

MPRSA - Marine Protection Research and Sanctuaries Act

NAAQS - National Ambient Air Quality Standards

NATURAL Resource Trustee -

NPL - National Priorities List: A list of sites identified for remediation under CERCLA.

NCP - National Oil and Hazardous Substances Contingency Plan

NEPA - National Environmental Policy Act

NIOSH - National Institute for Occupational Safety and Health

NPDES - National Pollutant Discharge Elimination System

O&M - operation and maintenance

OSHA - Occupational Safety and Health Administration

OSWER - Office of Solid Waste and Emergency Response

Operable unit - A discrete action that comprises an incremental step(s) toward a final remedy. Operable units may address geographic portions of a site, specific site problems, or this initial phase of an action.

Pilot scale - Treatability tests performed on a large scale to simulate the physical, as well as chemical, parameters of a process.

q_1^* - cancer potency factor: The lifetime cancer risk for each additional mg/kg body weight per day of exposure.

Present worth analysis - A summary of costs to be incurred over a period of time, discounted to the present.

PRP - potentially responsible party

QAPP - quality assurance project plan: A plan that describes protocols necessary to achieve the data quality objectives defined for an RI. (See SAP.)

RAS - routine analytical services

RCRA - Resource Conservation and Recovery Act

RD - remedial design

Reference dose (RfD) - For noncarcinogenic effects, the amount of a chemical that can be taken into the body each day over a lifetime without causing adverse effects.

Remedial action alternative - A potential approach to preventing or mitigating site-specific contamination problems, defined in terms of a remedial action technology option or combination of options and the volumes or areas of media to which the option or options will be applied.

Remedial action objective - A description of remedial goals for each medium of concern at a site; expressed in terms of the contamination of concern exposure route(s) and receptor(s), and maximum acceptable exposure level(s).

Remedial action technology type (or technology type) - A general category encompassing a number of remedial action technology options that address a similar problem (e.g., capping, containment barriers, chemical treatment).

Remedial action technology process option (or process option) - A specific process, system, or action that may be used to clean up or mitigate contaminant problems (e.g., clay cap, slurry wall, neutralization).

RfD - reference dose

RI/FS - remedial investigation/feasibility study

ROD - Record of Decision: Documents selection of cost-effective Superfund-financed remedy.

RPM - Remedial Project Manager: The project manager for the lead Federal agency.

SAP - sampling and analysis plan, consisting of a quality assurance project plan (QAPP) and a field sampling plan (FSP).

SARA - Superfund Amendments and Reauthorization Act of 1986. (See CERCLA.)

SAS - special analytical services

SDWA - Safe Drinking Water Act

Sensitivity analysis - A test of a procedure to determine the overall changes that will result from any small change in one or more procedural elements.

SITE - Superfund innovative technology evaluation

Support Agency - The agency, either the Federal EPA or the State agency, responsible for review and concurrence in developing and selecting a remedy at a CERCLA site.

SWDA - Solid Waste Disposal Act

TAT - technical assistance team

TCL - target compound list

Technology process option - See remedial action technology process option.

Technology type - See remedial action technology type.

TSCA - Toxic Substances Control Act

Treatability studies - Studies performed to better define the physical and chemical parameters of technology process options being evaluated.

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CHAPTER 1
INTRODUCTION

1.1 PURPOSE AND OBJECTIVES

This guidance document is a revision of the Environmental Protection Agency's (EPA) "Guidance on Remedial Investigations Under CERCLA" (May 1985) and "Guidance on Feasibility Studies Under CERCLA" (April 1985). These guidances have been consolidated into a single document and revised to (1) reflect new emphasis and provisions of the Superfund Amendments and Reauthorization Act (SARA), (2) incorporate aspects of new or revised guidance related to remedial investigations and feasibility studies (RI/FSs), (3) incorporate management initiatives designed to streamline the RI/FS process, and (4) reflect experience from previous RI/FS projects.

The purpose of this guidance is to provide the user with an overall understanding of the RI/FS process. Potential users include EPA personnel, State agencies responsible for coordinating or directing activities at National Priorities List (NPL) sites, potentially responsible parties (PRPs), Federal facility coordinators, and consultants or companies contracted to assist in RI/FS-related activities at NPL sites. This guidance describes the general procedures for conducting an RI/FS. Where specific guidance is currently available elsewhere, the RI/FS guidance will simply highlight the key points or concepts as they relate to the RI/FS process and refer the user to the other sources for additional details.

The Agency's experience to date in the Superfund program has clearly shown that there is a need for flexibility in the RI/FS process, and that the wide variety of Superfund sites requires that the process be tailored to meet site-specific needs. For example, large, complex sites will generally require a greater level of effort with intermediate deliverables necessary for each phase of the RI/FS process, whereas less complicated sites may not.

Therefore, the lead agency's remedial project manager and the RI/FS contractor must thoroughly consider the site conditions, scheduling constraints, budget limitations, and support agency input, when developing site-specific work plans to ensure that the RI/FS provides sufficient information to support the evaluation of remedial alternatives and the selection of a remedy, and at the same time is as streamlined as possible.

1.2 OVERVIEW OF CERCLA REAUTHORIZATION

The Superfund Amendments and Reauthorization Act (SARA) was signed by the President on October 17, 1986, to amend the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). While SARA did not change the basic structure of CERCLA, it did modify many of the existing requirements and added new ones. References made to CERCLA throughout this document should be interpreted as meaning "CERCLA as amended by SARA."

Many of the new provisions under CERCLA having the greatest impact on the RI/FS process are contained in §121 (Cleanup Standards). Other notable changes are contained in §104 (Response Authorities, in particular Health-Related Authorities), portions of §104 and §121 regarding State involvement, §117 (Public Participation), §110 (Worker Protection Standards), and §113 (Civil Proceedings). Highlights of these sections are summarized below.

1.2.1 Cleanup Standards

Section 121 (Cleanup Standards) states a strong statutory preference for remedies that are highly reliable and provide long-term protection. In addition to the requirement for remedies to be both protective of human health and the environment and cost-effective, additional remedy selection considerations in §121(b) include:

- A preference for remedial actions that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous substances, pollutants, and contaminants as its principal element.

- Offsite transport and disposal without treatment is the least favored alternative where practicable treatment technologies are available.

- The need to assess the use of permanent solutions and alternative treatment technologies or resource recovery technologies and use them to the maximum extent practicable.

Section 121(c) also requires a periodic review of remedial actions, at least every 5 years after initiation of such action, for as long as hazardous substances, pollutants, or contaminants that may pose a threat to human health or the environment remain at the site. If it is determined during a 5-year review that the action no longer protects human health and the environment, further remedial actions will need to be considered.

1.2.1.1 Applicable or Relevant and Appropriate Requirements

Section 121(d)(2)(A) of CERCLA incorporates into law the CERCLA Compliance Policy, which specifies that Superfund remedial actions meet any Federal standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate requirements (ARARs). Also included is the new provision that State ARARs must be met if they are more stringent than Federal requirements. Federal statutes that are specifically cited in CERCLA include the Solid Waste Disposal Act (SWDA), the Toxic Substances Control Act (TSCA), the Safe Drinking Water Act (SDWA), the Clean Air Act (CAA), the Clean Water Act (CWA), and the Marine Protection Research and Sanctuaries Act (MPRSA). Additional guidance on ARARs is provided in the "CERCLA Compliance with Other Environmental Laws Manual" (U.S. EPA Draft, November 1987).

Section 121(d)(4) of CERCLA identifies six circumstances under which ARARs may be waived:

- The remedial action selected is only a part of a total remedial action where the final remedy will attain the ARAR upon completion.

- Compliance with the ARAR will result in a greater risk to human health and the environment than alternative options.

- Compliance with the ARAR is technically impracticable from an engineering perspective.

- An alternative remedial action will attain an equivalent standard of performance through the use of another method or approach.

- The ARAR is a State requirement that the state has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances.

- For §104 Superfund-financed remedial actions, compliance with the ARAR will not provide a balance between protecting human health and the environment and the availability of Superfund money for response at other facilities.

1.2.1.2 Offsite Facilities

The new statutory requirements contained in §121(d)(3) for acceptable offsite disposal facilities, in most respects, incorporate previous Agency policy. Offsite disposal facilities receiving contaminants must be in compliance with RCRA and other Federal and State ARARs. In addition, the unit receiving the waste must have no releases to ground water, surface water, or soil; other units that have had releases at the facility must be under an approved corrective action program.

1.2.2 Health Assessments

Under CERCLA §104(i) (Health-Related Authorities), the Agency for Toxic Substances and Disease Registry (ATSDR) must conduct a health assessment for every site proposed for inclusion on the NPL. The purpose of these health assessments is to assist in determining whether current or potential risk to human health exists at a site and whether additional information on human exposure and associated health risks is needed. The health assessment is required to be completed "to the maximum extent practicable" before completion of the RI/FS.

1.2.3 State Involvement

Section 104(c)(3)(C) of CERCLA remains in effect requiring a 10-percent State cost share for remedial actions (remedial planning activities for the RI/FS and remedial design continue to be 100 percent federally funded). Section 104(c)(3)(A) and 104(c)(6) of CERCLA provide that the operation and maintenance of ground- and surface-water restoration actions be considered part of remedial action for up to 10 years after commencement of operations or until remedial action is complete, whichever is earlier. Therefore, such activities during the 10-year period would be eligible for 90 percent Federal funding.

Section 121(d)(2)(A) of CERCLA specifies that more stringent State ARARs apply and that these requirements must be identified in a timely manner by the state. Section 121(f) requires EPA to develop State involvement regulations for substantial and meaningful State involvement in the remedial response process.

1.2.4 Community Involvement

Section 117 of CERCLA (Public Participation) emphasizes the importance of early, constant, and responsive relations with affected communities and codifies, with some modifications, current community relations activities applied at NPL sites. Specifically, the law requires that notice of the

proposed remedial actions plan be published and that people be given a "reasonable opportunity" to comment on the proposed plan in writing, in person, and at a public meeting. The proposed plan should include a reasonable explanation of the alternatives considered, which will usually be in the form of a summary of the feasibility study. Notice of the final plan adopted and an explanation of any significant changes from the proposed plan are also required. CERCLA also authorizes technical assistance grants for local citizens' groups potentially affected by an NPL site. The grants are to be used in obtaining assistance in interpreting information on the nature of hazards posed by the site, the results of the RI/FS, any removal actions, the Record of Decision (ROD), and the remedial action and remedial design.

1.2.5 Worker Safety

Section 110 of CERCLA directed the Occupational Safety and Health Administration (OSHA) to issue, within 60 days of the date of enactment of SARA, an interim final rule that contains employee protection requirements for workers engaged in hazardous waste operations. OSHA's interim final rule (29 CFR 1910.120) was published in the Federal Register on December 19, 1986, with full implementation of this rule required by March 16, 1987. The worker safety rule will remain in effect until the final standard is issued by OSHA and becomes effective.

1.2.6 Administrative Record

Section 113(K) of CERCLA requires that an administrative record be established "at or near the facility at issue." The record must be available to the public and must include all information considered or relied on in selecting the remedy, including public comments on the proposed plan.

1.3 THE RI/FS PROCESS UNDER CERCLA

Although the new provisions of CERCLA have resulted in some modifications to the RI/FS process, the basic components of the process

remain intact. The RI continues to serve as the mechanism for collecting data for site and waste characterization and for conducting treatability testing as necessary to evaluate the performance and cost of the treatment technologies and support the design of selected remedies. The FS continues to serve as the mechanism for the development, screening, and detailed evaluation of potential remedial alternatives.

The various steps, or phases, of the RI/FS process and how they have been modified to comply with the new provisions in CERCLA are summarized below. It is important to note that the RI and FS are conducted concurrently and that data collected in the RI influence the development of remedial alternatives in the FS, which in turn affects the data needs and scope of treatability studies and additional field investigations. Two concepts are useful to understand the phased RI/FS. First, data can be collected in several stages, with initial data collection efforts usually being limited to developing a general understanding of the site. As the site is better characterized, subsequent data collection efforts can be focused to fill any existing gaps in the data. Second, this phased sampling approach encourages identification of key data needs as early in the process as possible to ensure that data collection is always directed toward providing information relevant to selection of a remedial action. In this way the overall site characterization effort can be continually scoped to minimize the collection of unnecessary data and maximize data quality.

Because of the interactive and iterative nature of this process, the sequence of the various phases and associated activities, as described below and presented in Figure 1-1, will frequently be less distinct in practice. A generic timeline intended to illustrate the phasing of RI/FS activities, is presented in Figure 1-2. The actual timing of individual activities will depend on specific site situations.

1.3.1 Scoping

Scoping is the initial planning phase of the RI/FS process, and many of the planning steps begun here are continued and refined in later phases of

FIGURE 1-1

PHASED RI/FS PROCESS

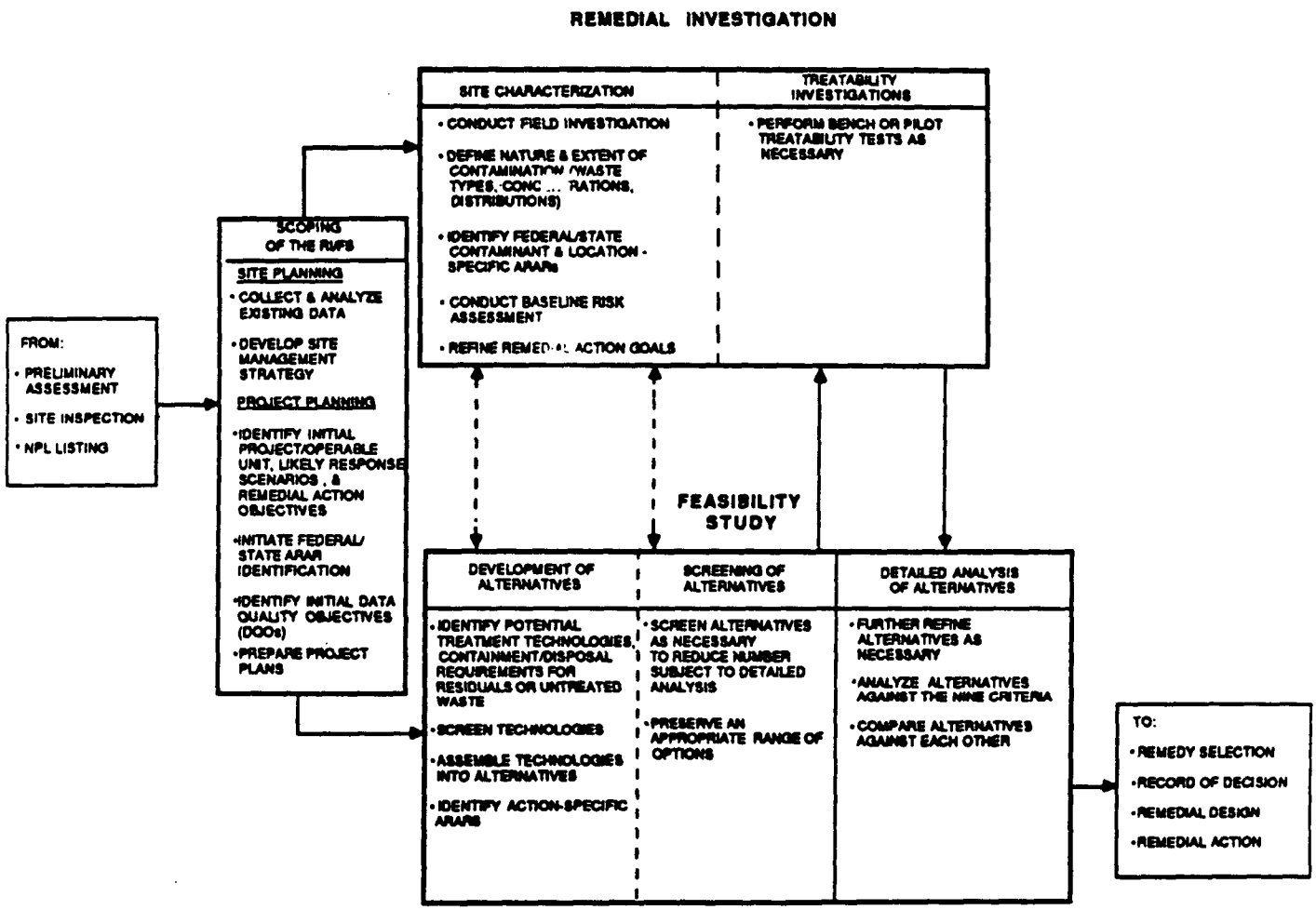
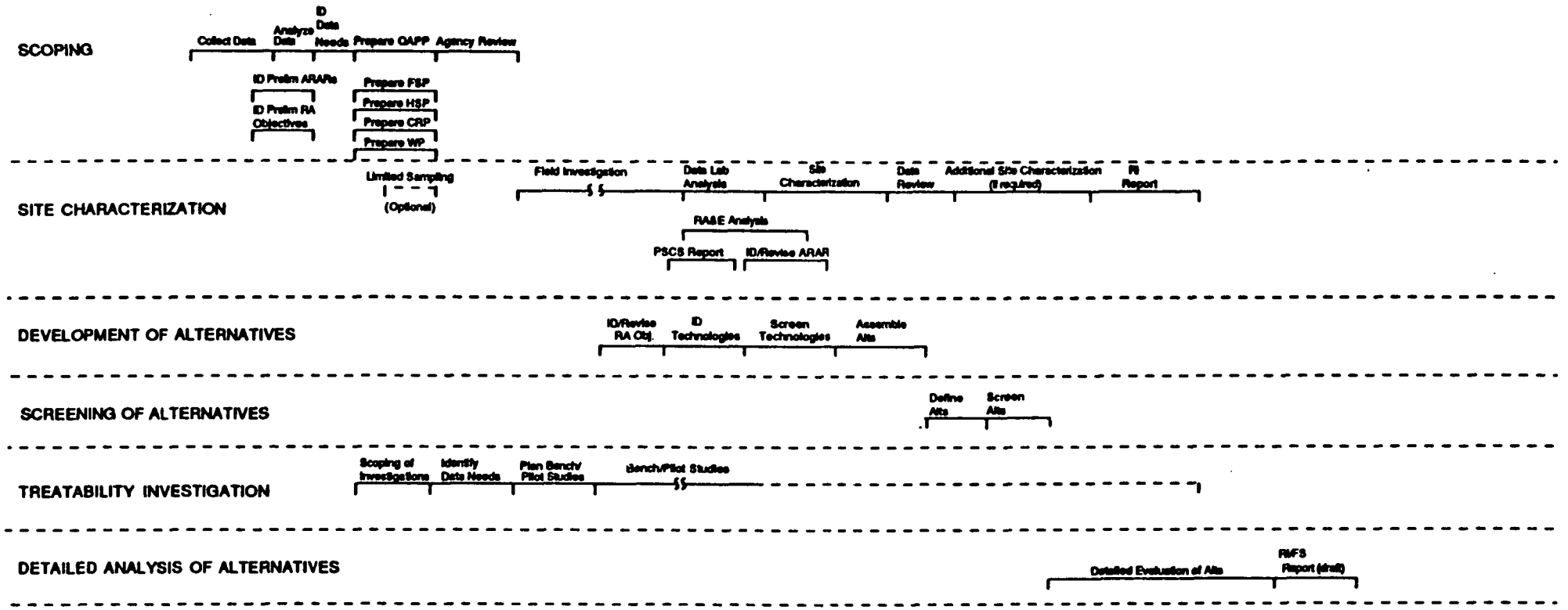


FIGURE 1-2

GENERIC PHASED RI/FS TIMELINE



the RI/FS. Scoping activities typically begin which the collection of existing site data, including data from previous investigations such as the preliminary assessment and site investigation. On the basis of this information, a site management strategy is developed that preliminarily identifies boundaries of the study area, identifies likely remedial action objectives and whether interim actions may be necessary or appropriate, and establishes whether the site may best be remedied as separate operable units. Once the site management strategy is developed, the RI/FS for a specific project or the site as a whole is scoped. Typical scoping activities include:

- Initiating the identification and discussion of potential ARARs with the support agency
- Determining the types of decisions to be made and identifying the data needed to support those decisions
- Developing initial data quality objectives
- Assembling a technical advisory committee to assist in these activities and to serve as a review board of important deliverables and to monitor progress as appropriate during the study
- Preparing the work plan, the sampling and analysis plan (SAP) (which consists of the quality assurance project plan (QAPP) and the field sampling plan (FSP)), the health and safety plan, and the community relations plan

Chapter 2 describes the various steps in the scoping process and gives general information on work planning methods that have been effective in planning and executing past RI/FSs.

1.3.2 Site Characterization

During site characterization, field sampling and laboratory analyses are initiated. Field sampling should be phased so that the results of the initial sampling efforts can be used to refine plans developed during scoping to better focus subsequent sampling efforts. Remedial response objectives are revised as appropriate based on an improved understanding of the site. This type of approach allows for a more efficient and accurate characterization of the site and, therefore, reductions in time and cost.

A preliminary site characterization summary is prepared to provide the lead agency with information on the site early in the process before preparation of the RI report. This summary will be useful in determining the feasibility of potential technologies and in assisting both the lead and support agencies with the initial identification of ARARs. It can also be sent to ATSDR to assist them in performing the health assessment for the site.

A baseline risk assessment is developed to identify the existing or potential risks that may be posed to human health and the environment by the site. These assessments also serve to support the evaluation of the no-action alternative by documenting the threats posed by the site based on expected exposure scenarios. Because these assessments identify the primary health and environmental threats at the site, they also provide valuable input to the development and evaluation of alternatives during the FS. Site characterization activities are described in Chapter 3.

1.3.3 Development of Alternatives

The development of alternatives usually begins during or soon after scoping, when likely response scenarios may first be identified. The development of alternatives requires (1) identifying potential treatment technologies; (2) screening the technologies based on their effectiveness, implementability, and cost (although cost plays a limited role at this phase); and (3) assembling technologies and their associated containment or

disposal requirements into alternatives for the contaminated media at the site or for the operable unit. Alternatives can be developed to address contaminated media (e.g., ground water), a specific area of the site (e.g., a waste lagoon or contaminated hot spots), or the entire site. Alternatives for specific media and site areas can be either carried through the FS process separately or combined into comprehensive alternatives for the entire site. The approach is flexible to allow alternatives to be combined at various points in the process. However, the final detailed evaluation must be for alternatives that address the entire site or that portion of the site being addressed by that specific operable unit.

As practicable, a range of treatment alternatives should be developed, varying primarily in the extent to which they rely on long-term management of residuals and untreated wastes. The upper bound of the range would be an alternative that would eliminate, to the extent practicable, the need for any long-term management (including monitoring) at the site. The lower bound would consist of an alternative that involves treatment as a principal element (i.e., treatment is used to address the principal threats at the site). Between the upper and lower bounds of the treatment range, alternatives varying in the type and degrees of treatment and associated containment/disposal requirements should be included as appropriate. In addition, one or more containment options involving little or no treatment and a no-action alternative should be developed as appropriate. The development of alternatives is discussed in Chapter 4.

1.3.4 Screening of Alternatives

Once potential alternatives have been developed, it may be necessary to screen out certain options to reduce the number of alternatives that will be analyzed in detail in order to minimize the resources dedicated to evaluating options that are less promising. The necessity of this screening effort will be dependent on the number of alternatives initially developed, which will be partially dependent on the complexity of the site and/or the number of available/suitable technologies. In these situations where it is necessary to reduce the initial number of alternatives prior to beginning

the detailed analysis, a range of alternatives should be preserved as practicable so that the decisionmaker can be presented with a range of good options from which to choose. The screening process involves evaluating alternatives with respect to their effectiveness, implementability, and cost. It is often done on a general basis and with limited effort (relative to the detailed analysis) because the necessary information to fully evaluate the alternatives may not be complete at this point in the process. The screening of alternatives is discussed in Chapter 5.

1.3.5 Treatability Investigations

Should existing site and/or treatment data be insufficient to adequately evaluate alternatives, treatability tests may be necessary to evaluate a particular technology on specific site wastes. Generally, treatability tests involve bench-scale testing to gather information to assess the feasibility of a technology. In a few situations, a pilot-scale study may be necessary to furnish performance data and develop better cost estimates so that a detailed analysis can be performed and a remedial action can be selected. To conduct a pilot-scale test and keep the RI/FS on schedule, it will usually be necessary to identify and initiate the test at an early point in the process. Treatability investigations are described in Chapter 6.

1.3.6 Detailed Analysis

Once sufficient data are available, alternatives are evaluated in detail with respect to nine evaluation criteria which the Agency has developed to address the statutory requirements and preferences of CERCLA. The alternatives are analyzed individually against each criterion and then compared against one another to determine the respective strengths and weaknesses of each alternative and identify the key tradeoffs for that site. As discussed above, alternatives evaluated in this phase of the FS must address the entire site or that portion of the site being addressed by an operable unit. The results of the detailed analysis are summarized and presented to the decisionmaker so that an appropriate remedy consistent with

CERCLA can be selected. The detailed analysis of alternatives is described in Chapter 7.

1.4 SPECIAL SITES

The use of treatment technologies, and therefore, the development of a complete range of options, may not be practicable at some sites with large volumes of low concentrated wastes (e.g., large municipal landfills or mining sites). Remedies involving treatment at such sites may be inhibitingly expensive or difficult to implement. Therefore, the range of alternatives initially developed may be focused primarily on various containment options. Although this guidance does not specifically state how all such sites should be addressed, factors are discussed that can be used as appropriate to help guide the development and evaluations of alternatives on a case-by-case basis.

1.5 COMMUNITY RELATIONS

Community relations are a useful and important aspect of the RI/FS process. Community relations activities serve to keep communities informed of the activities at the site and helps the Agency anticipate and respond to key community concerns. A community relations plan is developed for a site as the work plan for the RI/FS is prepared. The community relations plan is based on interviews with interested people in the community and will provide the guidelines for future community relations activities at the site. At a minimum, the plan must provide for a site mailing list, a conveniently located place for access to all public information about the site, an opportunity for a public meeting when the RI/FS report and proposed plan are published, and a summary of public comments on the RI/FS report and proposed plan and the Agency's response to those comments.

The specific community relations requirements for each phase of the RI/FS are integrated throughout this guidance document, since they are parallel to and support the technical activities. Each chapter has a section discussing community relations requirements appropriate to that

specific phase of the RI/FS. Additional program requirements are described in the March 1986 draft of OSWER Directive Number 9230.0-3A entitled "Community Relations in Superfund: A Handbook."

1.6 LEAD AND SUPPORT AGENCY

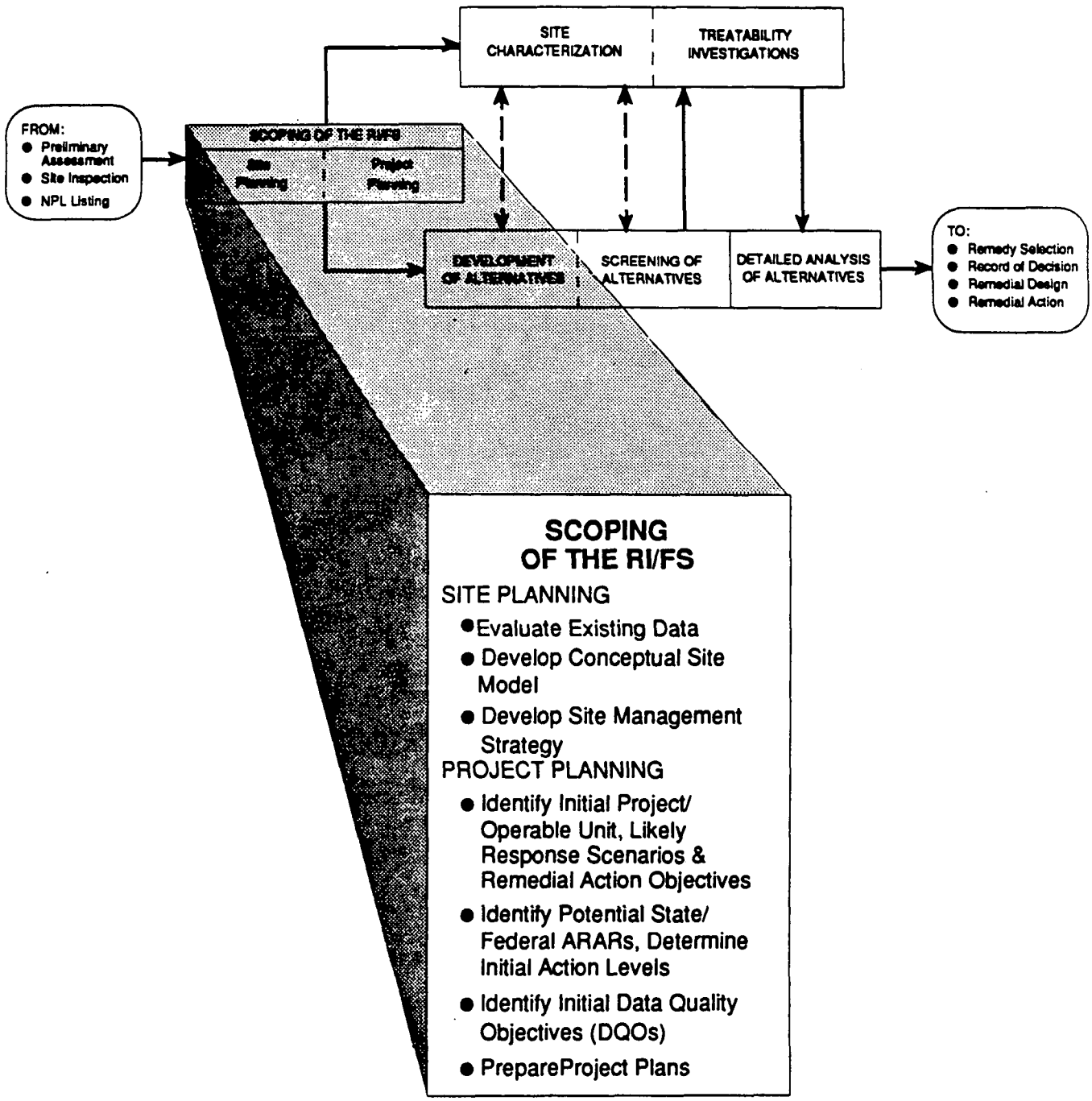
Throughout this guidance the terms "lead agency" and "support agency" are used to reflect the fact that either EPA or a State or Federal facility can have the lead responsibility for conducting an RI/FS. The supporting agency plays a review and concurrence role and provides specific information, such as applicable or relevant and appropriate requirements. The roles of the lead and support agencies in each phase of the RI/FS process are described at the end of each chapter.

1.7 RPM ROLE AND RESPONSIBILITIES

The RPM's role in overseeing an RI/FS involves, to a large extent, ensuring the work progresses in accordance with the priorities and objectives established during site and project planning. This will require the facilitation of interactions among EPA staff, state representatives, contractor personnel, PRPs, and the public, to ensure that all involved parties are aware of their roles and responsibilities. Throughout the following chapters, and particularly in the discussions of scoping (Chapter 2) and site characterization (Chapter 3), suggestions are provided to guide the RPM in developing approaches for conducting RI/FSs so that high quality deliverables are produced in a timely and cost-effective manner. Additional suggestions specific to management of RI/FSs may be found in the Superfund Federal Lead Remedial Project Manager Handbook and Superfund State Lead Remedial Project Manager Handbook. Oversight responsibilities for PRP-lead RI/FSs are outlined in Appendix A of this guidance.

WDR314/035

CHAPTER 2
SCOPING OF THE RI/FS



CHAPTER 2
SCOPING THE RI/FS

2.1 INTRODUCTION

Scoping is the initial planning phase of site remediation and is begun, at least informally, by the lead agency's remedial project manager as part of the funding allocation and planning process. The first step in scoping is site planning, which involves developing a site management strategy to facilitate better planning and management of site activities. The lead and support agencies should meet to develop a site management strategy on the basis of available information that will serve to (1) identify the types of actions that may be required to address site problems; (2) identify whether interim actions may be taken to mitigate potential threats or prevent further environmental degradation; (3) identify the optimal sequence of site actions and site activities; and (4) identify procedures that may be used to streamline the RI/FS.

Once the initial site management strategy is developed and both the lead and support agencies agree on the basic approach, the next step is to scope the specific project(s) and develop project plans. Project planning is done for the following reasons:

- Determine the types of decisions to be made
- Identify the data needed to support those decisions
- Describe the methods by which the required data will be obtained
- Describe the methods by which the data will be analyzed
- Prepare work plans to document methods and procedures

These activities directly relate to the establishment of data quality objectives (DQOs)--statements that specify the data needed to support decisions regarding remedial response activities. Establishing DQOs are discussed in

detail in Data Quality Objectives for Remedial Response Activities (OSWER Directive 9335.0-7B, March 1987, hereafter referred to as the DQO Guidance).

The ability to develop a comprehensive site management strategy or adequately scope a specific project is closely tied to the amount and quality of information available at the time. Therefore, it is important to note that the site management strategy and project scope is developed iteratively (i.e., as new information is acquired or new decisions are made, data requirements are reevaluated and, if appropriate, the site management strategy or project scope is modified). In this way, scoping helps to focus activities and streamline the RI/FS, thereby preventing needless expenditures and loss of time in unnecessary sampling and analyses.

Figure 2-1 shows the key steps in the scoping process.

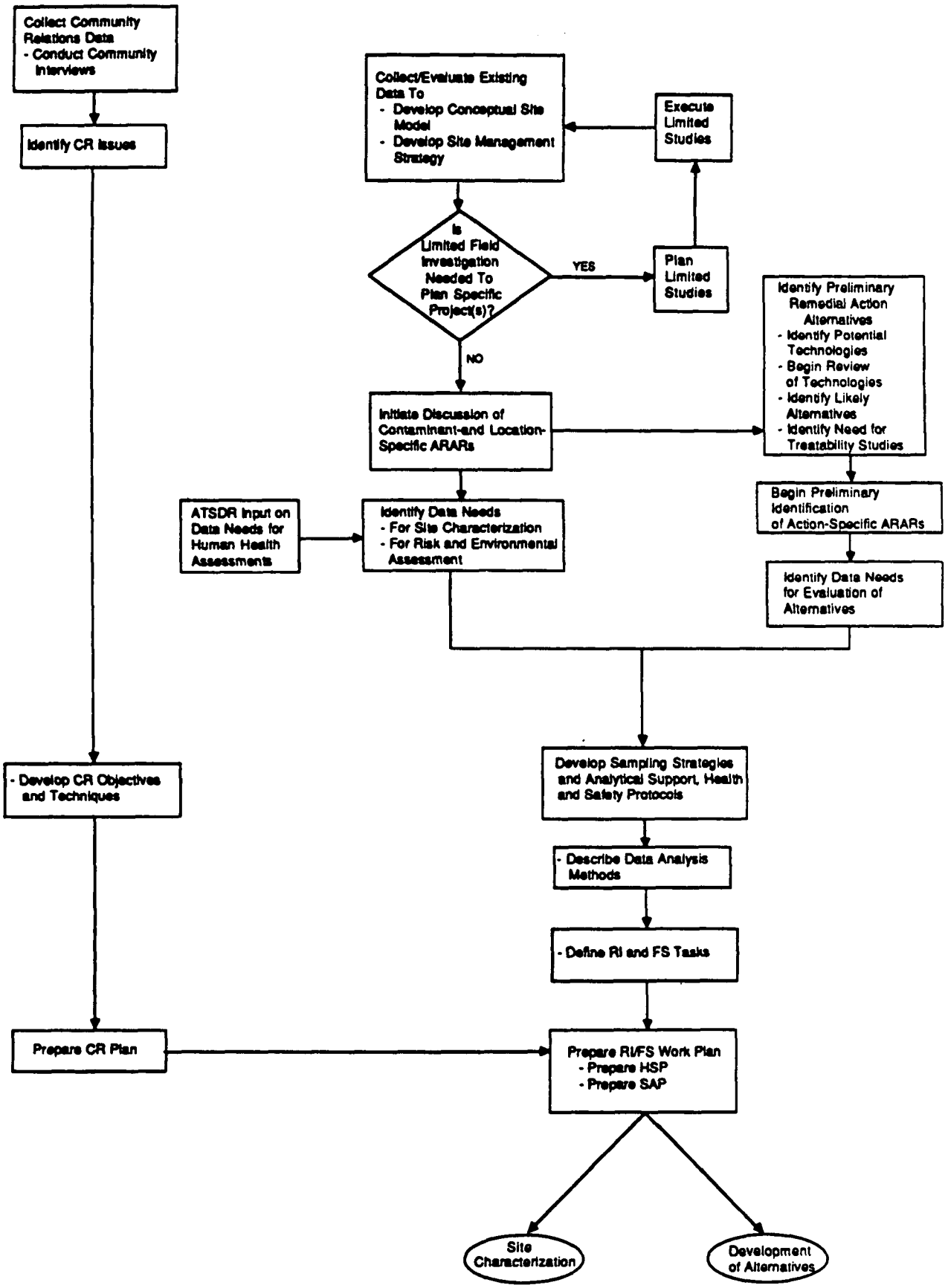
2.2 SITE PLANNING

2.2.1 Develop a Site Management Strategy

One purpose for developing the site management strategy is to facilitate the identification of potential action that can be taken early to respond to an immediate problem that is worsening with time or to undertake a limited action that will achieve a significant risk reduction quickly. If the site response is to involve an interim action or is to be implemented through operable units, the lead and support agencies should identify the optimal sequence of the actions. Operable units may comprise incremental steps toward the final remedy, completely address a geographical portion of the site or a specific site problem, or initiate action that must be followed by a final action that will fully address the problem. The interrelationship of site problems and the need to implement actions quickly will determine the appropriateness of dividing a remedial response into separate operable units and/or taking interim actions. To the degree that site problems are interrelated, (e.g., contaminated soils and ground water), it may be appropriate to address the problems together. If problems are separate, phased responses may promote a more rapid and effective cleanup.

FIGURE 2-1

SCOPING



Although the need for interim actions or for separating the site into operable units may not be identified until the RI is under way, the site information available during scoping should be evaluated so that the site management strategy can identify whether either is likely. Specific project scoping can then be used to identify the data that are necessary to conduct the RI/FS for that site or operable unit.

The timing and optimal sequencing of response actions should be identified as part of the site management strategy to ensure that the most important activities are to be implemented first. The timing of specific actions should be determined on the basis of the urgency of response, the ability to take rapid action, and the resources to fund and administer response actions. The identified sequence of activities and actions should be reevaluated periodically as new information becomes available.

2.2.2 Identify Streamlining Techniques

During the development of the site management strategy, an initial attempt at tailoring the RI/FS to site circumstances should be made. Tailoring the RI/FS to the level of site complexity does not change information requirements but simply involves identifying specific techniques that may be used to streamline the process in order to save time and costs while ensuring that information is sufficient in quantity and quality to select an appropriate remedy. Examples of streamlining techniques that may be used in appropriate situations include:

- Focusing the remedial investigation to collect only those data needed to develop and evaluate alternatives for a specified response action and to support the design of that action

- Combining the alternative development and screening steps or, when only a limited number of viable options are available, eliminating the screening step

- Tailoring the level of detail of the alternative evaluation to the scope and complexity of the action

- Tailoring selection and documentation of the remedy to the scope of the action (non-final remedies may require less justification and documentation than final remedies)

The extent to which streamlining techniques may be used will depend on site conditions. For example, the development of a range of treatment alternatives may not be appropriate for sites with extremely large volumes of low concentration wastes, (e.g., large landfills and mining sites). Although such a decision may not be finalized until later in the RI/FS process, it is important that the lead and support agencies agree that treatment technologies may not be appropriate. Examples of other site-specific characteristics or situations that may be conducive to streamlining techniques include:

- A single group of chemicals or site characteristics such as fractured bedrock significantly limits applicable technologies.

- The need for prompt action limits the time available to evaluate a complete range of alternatives in detail.

- ARARs, guidance, or program precedent (e.g., PCB standard for soils, Superfund Drum and Tank Guidance) limits the choices for appropriate responses.

- Prohibitive costs for certain alternatives reduce the range of viable options to address site problems.

- There is a strong probability that no further action is required.

2.3 PROJECT PLANNING

Once the site management strategy has been developed and potential streamlining techniques have been identified, planning the specific project scope follows. The specific steps to project planning include:

- Meeting with EPA regional, state, and contractor personnel to discuss site issues and assign responsibilities for RI/FS activities

- Collecting and analyzing existing data to develop a conceptual site that can be used to assess both the nature and the extent of contamination and to identify potential exposure pathways and potential human health and/or environmental receptors

- Initiating limited field investigations if available data are inadequate to develop a conceptual site model and adequately scope the project

- Identifying the potential remedial action objectives and likely remedial action alternatives for the specific project

- Identifying the need and the schedule for treatability studies to better screen and define the potential remedial alternatives

- Preliminarily identifying the ARARs expected to apply to both site characterization and site remediation activities

- Determining data needs and the level of analytical and sampling certainty required for additional data if currently available data are inadequate to conduct the FS

- Designing a data collection program to describe the selection of the sampling approaches and analytical options (This selection is documented in the SAP, which consists of the FSP and QAPP elements.)

- Developing a work plan that documents the scoping process and presents anticipated future tasks

- Identifying and documenting health and safety protocols required during field investigations and preparing a site health and safety plan

- Conducting community interviews to obtain information that can be used to develop a site-specific community relations plan that documents the objectives and approaches of the community relations program

Although each of the steps is discussed below, it should be noted that one or more of them may have been performed to some extent during the development of the site management strategy.

2.3.1 Conduct Scoping Meeting

To begin project planning, a meeting should be held involving key management from the lead and support agencies, along with contractor personnel who will be conducting the RI/FS. The meeting allows key personnel to become involved in initial planning decisions; it also gives them the opportunity to discuss any special concerns that may be associated with the site. Furthermore, this meeting sets a precedent for the continued involvement of key personnel periodically throughout the project.

2.3.2 Collect and Analyze Existing Data

Before the activities necessary to conduct an RI/FS can be planned, it is important to compile all available data that have previously been collected for a site. These data will be used to determine the additional work that needs to be conducted both in the field and within the community. A thorough search of existing data should help avoid duplication of previous efforts and/or lead to a remedial investigation that is more focused and, therefore, more efficient in its expenditure of resources.

Information describing hazardous waste sources, migration pathways, and human and environmental receptors for a given site is available from many sources. Some of the more useful sources are listed in Table 2-1. Site information gathered in the hazard ranking process (the process by which a site is listed on the NPL) may be located in files maintained by the EPA Regional offices, the field investigation team (FIT), the technical assistance team (TAT), contractors, and the state.

Data relating to the varieties and quantities of hazardous wastes disposed of at the site should be compiled. The results from any previous sampling events should be summarized in terms of physical and chemical characteristics, contaminants identified, and concentrations present. Results of environmental sampling at the site should be summarized, and evidence of soil, ground water, surface water, sediment, air, or biotic contamination should be documented. If available, information on the precision and accuracy of the data should be included.

Records of disposal practices and operating procedures at the site, including historical photographs, can be reviewed to identify locations of waste materials onsite, waste haulers, and waste generators. If specific waste records are absent, waste products that may have been disposed of at the site can be identified through a review of the manufacturing processes of the waste generators.

A summary of existing site-specific and regional information should be compiled to help identify surface, subsurface, atmospheric, and biotic migration pathways. Compiled information should include geology, hydrogeology, hydrology, meteorology, and ecology. Regional information can help to identify background soil, water, and air quality characteristics.

Data on human and environmental receptors in the area surrounding the site should be compiled. Demographic and land use information will help identify potential human receptors. Residential, municipal, or industrial wells should be located, and surface water uses should be identified for surrounding areas and areas downstream of the site.

TABLE 2-1. DATA COLLECTION INFORMATION SOURCES

Information Source	Hazardous Waste Sources	Migration Pathways: Subsurface	Migration Pathways: Surface	Migration Pathways: Air	Receptors
U.S. EPA Files	X	X	X	X	X
U.S. Geological Survey		X	X		
U.S. DOA, Soil Conservation Service[a]		X	X		
U.S. DOA, Agricultural Stabilization and Conservation Service		X	X		
U.S. DOA, Forest Service			X		X
U.S. DOI, Fish and Wildlife Agencies					X
U.S. DOI, Bureau of Reclamation	X	X	X		
U.S. Army Corps of Engineers	X				
Federal Emergency Management Agency[b]			X		
U.S. Census Bureau					X
National Oceanic and Atmospheric Administration				X	
State Environmental Protection or Public Health Agencies	X	X	X	X	X
State Geological Survey		X	X		
State Fish and Wildlife Agencies					X
Local Planning Boards		X	X	X	X
County or City Health Departments	X	X	X	X	X
Town Engineer or Town Hall	X				X
Local Chamber of Commerce	X				X
Local Airport				X	
Local Library		X			X
Local Well Drillers		X			
Sewage Treatment Plants	X	X	X		
Local Water Authorities		X			X
City Fire Departments	X	X	X	X	
Regional Geologic and Hydrologic Publications		X	X		
Court Records of Legal Action	X				
Department of Justice Files	X				
State Attorney General Files	X				
Facility Records	X				
Facility Owners and Employees[c]	X	X			X
Citizens Residing Near Site[c]	X	X	X	X	X
Waste Haulers and Generators[c]	X				
Site Visit Reports	X		X	X	X
Photographs	X		X		X
Preliminary Assessment Report	X	X	X	X	X
Field Investigation Analytical Data	X	X	X	X	
FIT/TAT Reports	X	X	X	X	X
Site Inspection Report	X	X	X	X	X
HRS Scoring Package	X	X	X	X	X
EMSL/EPIC (Environmental Monitoring Support Laboratory/ Environmental Photographic Information Center)	X		X		X

[a]Includes county soil survey reports from Soil Conservation Service, U.S. DOA.
[b]The Federal Emergency Management Agency publishes floodplain maps.
[c]Interviews require EPA concurrence.

The ecology of the site and surrounding areas should be described and the common flora and fauna of the area identified. Any threatened, endangered, or rare species on or near the site should also be identified, as should sensitive environmental areas or critical habitats. Any available results from biological testing should be compiled to document bioaccumulation in the food chain.

Once the available data have been collected, they are analyzed to: (1) establish the physical characteristics of a site to help determine the scope of future sampling efforts; and (2) conceptually model potential exposure pathways and receptors to assist in the preliminary assessment of risk and the initial identification of potential remedial technologies. Each of these uses is discussed below.

2.3.2.1. Establish Physical Characteristics of the Site

Existing data are analyzed to gain a better understanding of the nature and extent of contamination and of the pathways, receptors, and existing or potential effects of the site. The data should be used to develop a site description, which should include location, ownership, topography, geology, land use, waste type, estimates of waste volume, and other pertinent details. The extent of contamination for the various media should be determined for use in designing remedial investigation tasks.

The site description should also include historical events of concern such as chemical storage and disposal practices, previous site visits, sampling events, regulatory violations, legal actions, and changes in ownership. In addition, information concerning previous cleanup actions, such as removal of containerized waste, is often valuable for determining the characteristics of any wastes or contaminated media remaining at the site.

If quality assurance information on existing sampling data is available, it should be reviewed to assess the level of uncertainty associated with the data. This is important to establish whether sampling will be needed to verify or simply supplement existing data. Important factors to

consider when reviewing existing data are the comparability of the data (e.g., time of sampling), the analytical methods, the detection limits, the analytical laboratories, and the sample collection and handling methods.

It is also useful to compile a chronology of significant events. All sources of information or data should be summarized in a technical memorandum or retained for inclusion in the RI report.

2.3.3.2 Develop a Conceptual Site Model

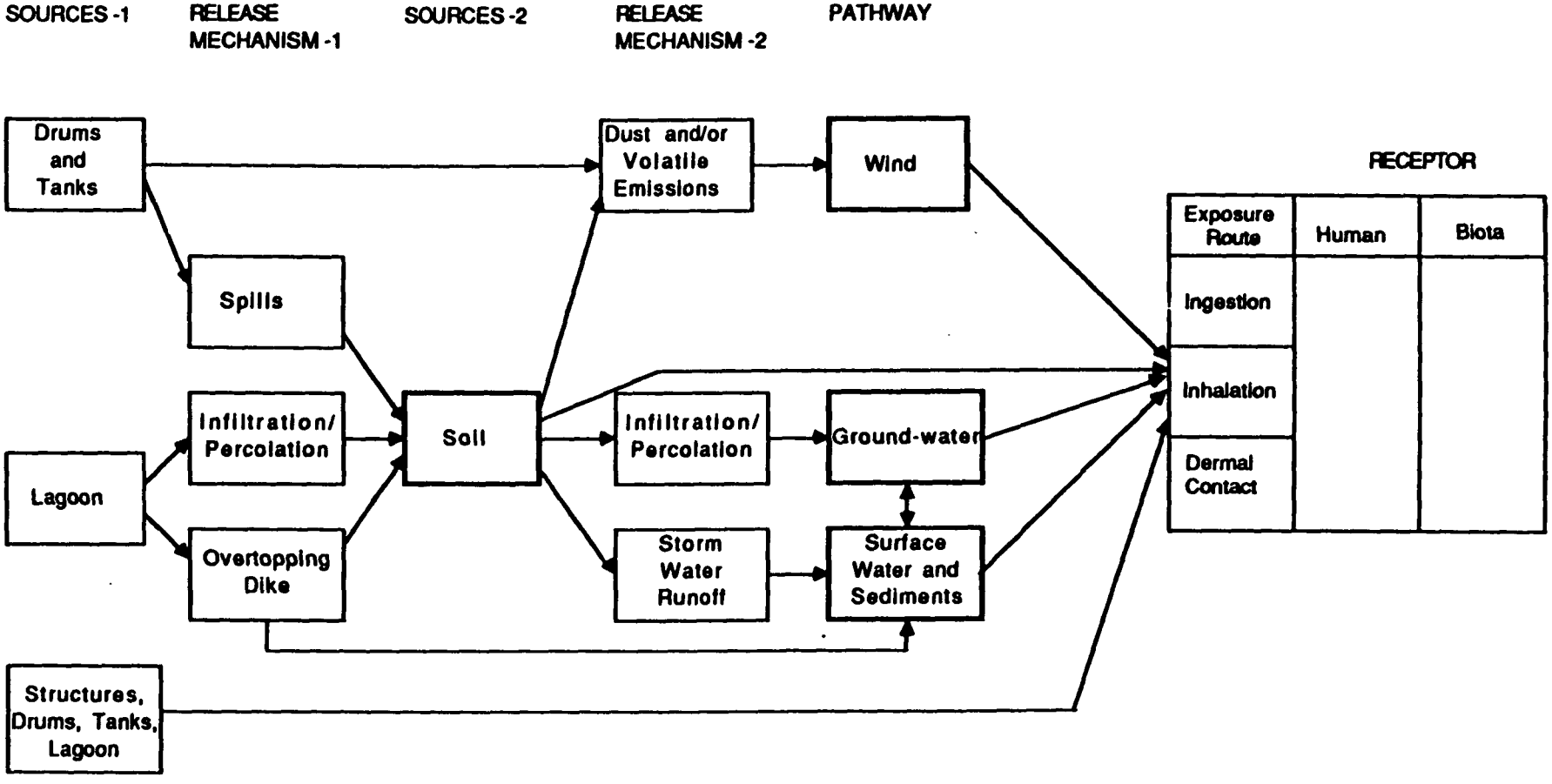
Information on the waste sources, pathways, and receptors at a site is used to develop a conceptual site model to evaluate potential risks to human health and the environment. The conceptual site model should include all known and suspected sources of contamination, types of contaminants and affected media, known and potential routes of migration, and all known or potential human and environmental receptors. If exact data are unavailable for components of the model, the likely variability in the component should be identified so that the model identifies the possible range of contaminant migration and the potential effects on receptors. This effort, in addition to assisting in identifying where samples need to be taken, will also assist in identifying appropriate remedial technologies. Additional information for evaluating exposure concerns through the use of a conceptual model is provided in the DQO Guidance. Figure 2-2 shows the elements to be contained in such a model.

2.3.3.3 Determine the Need for and Implement Limited Additional Studies

If the conceptual site model is poorly defined and the collection of site-specific data could greatly increase the understanding of the site, a limited field investigation may be undertaken as an interim scoping task prior to developing the work plan. Normally, the investigation is limited to easily obtainable data where results can be achieved in a short time. Examples of tasks are:

FIGURE 2-2

EXAMPLE CONCEPTUAL SITE MODEL



- Preliminary geophysical investigations
- Residential, industrial, and agricultural well sampling and analysis
- Measurement of well-water level, sampling (only for pre-existing monitoring wells), and analysis
- Limited sampling to determine the need for waste treatability studies
- Air monitoring
- Site mapping

Once these data are obtained and the conceptual site model is refined, data needs can be better defined.

2.3.4 Develop and Evaluate Preliminary Remedial Action Alternatives

Once the existing site information has been analyzed and the conceptual site model developed, potential remedial action objectives should be identified for each contaminated medium (Chapter 4 presents examples of remedial action objectives) and a preliminary range of remedial action alternatives and associated technologies should be identified. This identification is not meant to be a detailed investigation of alternatives. Rather, it is intended to be a more general classification of potential remedial actions based upon the initially identified potential routes of exposure and associated receptors. The identification of potential technologies at this stage will help ensure that data needed to conduct the technical evaluation (e.g., Btu value of wastes to evaluate thermal destruction technologies) can be collected as early as possible. In addition, the identification of technologies will help determine whether treatability studies need to be conducted.

Technologies that may be appropriate for treating or disposing of wastes should be identified, along with sources of literature on the technologies' effectiveness, applications, and cost. Further assistance in the investigation of technologies is provided in the "Technology Screening Guide" (U.S. EPA Draft 1987). Innovative technologies and resource recovery options should be included if they appear feasible.

To the extent practicable, a preliminary list of broadly defined alternatives should be developed that reflects the goal of presenting a range of good options to the decisionmaker. This list would therefore include a range of alternatives in which treatment significantly reduces the toxicity, mobility, or volume of waste; one or more alternatives that involve containment with little or no treatment; and a no-action alternative. The list should be limited to only those alternatives that are relevant and carry some significant potential for being implemented at the site. In this way, the preliminary identification of remedial actions will allow an initial identification of ARARs and will help focus subsequent data-gathering efforts.

Involvement of the various agencies at this time will help in identifying remedial alternatives and scoping field activities. The development of alternatives is described in more detail in Chapter 4 of this document.

2.3.5 Evaluate the Need for Treatability Studies

If remedial actions involving treatment have been identified for a site, then the need for treatability studies should be evaluated as early as possible in the RI/FS process. This is because many treatability studies, especially pilot testing, may take several months or more to complete. If a lengthy study is required and is not initiated early, the FS may be delayed while awaiting the results of the treatability testing.

The initial activities of treatability testing include researching other potentially applicable data, designing the study, and procuring vendors and equipment. As appropriate, these activities should occur

concurrently with site characterization efforts so that if it is determined that a potential technology is not feasible, treatability activities on this technology can be stopped before actual analysis of wastes has occurred. Chapter 6 provides guidance on scoping treatability studies.

2.3.6 Begin Preliminary Identification of ARARs and To Be Considered (TBC) Requirements

A preliminary identification of potential ARARs and TBC requirements in the scoping phase can assist in initially identifying remedial alternatives and is useful for initiating communications with the support agency to facilitate the identification of ARARs. Because of the iterative nature of the RI/FS process, ARAR identification continues throughout the RI/FS as a better understanding is gained of site conditions, site contaminants, and remedial action alternatives. Furthermore, early identification of potential ARARs will allow better planning of field activities.

ARARs may be categorized as contaminant-specific, which may define acceptable exposure levels and therefore be used in establishing preliminary cleanup goals; as location-specific, which may set restrictions on activities within specific locations such as floodplains or wetlands; and as action-specific, which may set controls or restrictions for particular treatment and disposal activities related to the management of hazardous wastes. The document, "Guidance on CERCLA Compliance With Other Statutes" (U.S. EPA, July 1987 Draft), contains detailed information on identifying and complying with ARARs.

Potential contaminant- and location-specific ARARs are identified on the basis of the compilation and evaluation of existing site data. A preliminary evaluation of potential action-specific ARARs may also be made to assess the feasibility of remedial technologies being considered at this time. In addition to Federal ARARs, more stringent State ARARs must also be identified. Other Federal and State criteria, advisories, and guidance and local ordinances should also be considered, as appropriate, in the development of remedial action alternatives.

For documentation purposes, a list should be maintained of all potential ARARs as they are identified for a site. As the RI/FS progresses, each ARAR will need to be ascertained. The assistance of the appropriate support agency should be sought in identifying support agency ARARs and confirming their applicability or relevance and appropriateness.

2.3.7 Identify Data Needs

The identification of data needs is the most important part of the scoping process. Data needs are identified by evaluating the existing data and determining what additional data are necessary to characterize the site, complete the conceptual site model, better define the ARARs, narrow the range of preliminarily identified remedial alternatives, and support enforcement activities.

The need for additional site data is evaluated relative to meeting the site-specific RI/FS objectives. In general, the RI/FS must obtain data to define source areas of contamination, the potential pathways of migration, and the potential receptors and associated exposure pathways to the extent necessary to:

- Determine whether, or to what extent, a threat to human health or the environment exists
- Develop and evaluate remedial alternatives (including the no-action alternative)
- Support enforcement or cost-recovery activities

If additional data are needed, the intended uses of the data are identified, strategies for sampling and analyses are developed, data quality objectives are established, and priorities are assigned according to the importance of the data in meeting the objectives of the RI/FS.

The possible use categories include:

- o Monitoring during implementation
- o Health and safety planning
- o Site characterization
- o Risk assessment
- o Evaluating alternatives
- o Determining the PRP
- o Engineering the design of alternatives

A more complete description of these use categories and their appropriate analytical levels can be found in the DQO Guidance. This is summarized in Figure 2-3.

Setting priorities for data use helps to determine the highest level of confidence required for each type of data. For example, additional data on soil contamination may be necessary for all the above categories but may be of highest priority for risk assessment and evaluation of alternatives. Within these two use categories, the evaluation of alternatives may require a much greater level of confidence in the contaminant types and concentrations onsite so that cost estimates for treatment can be prepared to meet or approach the goal of +50 percent/-30 percent accuracy level. As a result, data needs specifying the level of allowable uncertainty would be set for the evaluation of alternatives use category and would therefore provide an acceptable level of confidence for the remaining data uses.

Sensitivity analyses may be useful in evaluating the acceptable level of uncertainty in data. Critical parameters in any of the use categories can be varied over a probable range of values that were identified in the conceptual site model and that determine the effect on meeting the RI/FS objectives. For example, preliminary treatment costs for contaminated soil can be calculated for various contaminant types and volumes. The sensitivity that contaminant volume and type has on treatment cost can be assessed so that sufficient site characterization data are collected to allow costing

FIGURE 2-3

SUMMARY OF ANALYTICAL LEVELS APPROPRIATE TO DATA USES

DATA USES	ANALYTICAL LEVEL	TYPE OF ANALYSIS
Site Characterization Monitoring During Implementation	LEVEL I	• Total Organic/Inorganic Vapor Detection Using Portable Instruments • Field Test Kits
Site Characterization Evaluation of Alternatives Engineering Design Monitoring During Implementation	LEVEL II	• Variety of Organics by GC; Inorganics by AA; XRF • Tentative ID; Analyte-Specific • Detection Limits Vary from Low ppm to Low ppb
Risk Assessment PRP Determination Site Characterization Evaluation of Alternatives Engineering Design Monitoring During Implementation	LEVEL III	• Organics/Inorganics Using EPA Procedures other than CLP can be Analyte-Specific • RCRA Characteristic Tests
Risk Assessment PRP Determination Evaluation of Alternatives Engineering Design	LEVEL IV	• HSL Organics/Inorganics by GC/MS; AA; ICP • Low ppb Detection Limit
Risk Assessment PRP Determination	LEVEL V	• Non-Conventional Parameters • Method-Specific Detection Limits • Modification of Existing Methods • Appendix 8 Parameters

of treatment alternatives during the FS using a goal of +50 percent/ -30 percent cost accuracy.

In the development of data requirements, time and resource constraints must be balanced with the desired confidence level of the data. The turn-around time necessary for certain analytical procedures may, in some cases, preclude achieving the original level of confidence desired.

Likewise, resource constraints such as the availability of a laboratory, sampling and analysis equipment, and personnel may also influence the determination of data requirements. Because of the high cost of sampling and analysis for contaminants on the hazardous substances list, data acquisition should be focused only on the data quality and quantity necessary and sufficient to meet the RI/FS objectives. It is also important to do any necessary logistical planning once data needs are identified. For example, if it will be necessary to acquire aerial photographs to adequately evaluate a site, it should be noted early in the process so that the acquisition can begin early.

2.3.8 Design a Data Collection Program

Once the level of confidence required for the data is established, strategies for sampling and analysis can be developed. The identification of sampling requirements involves specifying the sampling design; the sampling method; sample numbers, types, and locations; and the level of sampling quality control. Data may be collected in multiple sampling efforts to use resources efficiently, and the level of accuracy may increase as the focus of sampling is narrowed. The determination of analytical requirements involves specifying the most cost-effective analytical method that, together with the sampling methods, will meet the overall data needs for the RI/FS. Data quality requirements specified for sampling and analysis include precision, accuracy, representativeness, completeness, and comparability.

A description of the methods to be used in analyzing data obtained during the RI should be included in a sampling and analysis plan (SAP). The level of detail possible in defining the data evaluation tasks will depend on the quality of the site conceptual model. If the site is well understood, data evaluation techniques should be specified and described. This information is especially important where numerical modeling is anticipated. If little existing information is available, the task descriptions may be very general, since it may not be clear which data evaluation techniques will be appropriate. If information is lacking, descriptions of potential evaluation techniques could be included. In addition to site characterization techniques, methods to be used in the risk assessment should be described.

2.3.9 Develop a Work Plan

Tasks that are to be conducted during the RI/FS should be identified and documented in a work plan. Although this work plan will constitute the planning through the completion of the RI/FS, the level of detail with which specific FS tasks can be described during scoping will depend on the amount and quality of existing data. Therefore, in situations in which additional data are needed to adequately scope the development and evaluation of alternatives, emphasis should be placed on limiting the level of detail used to describe these subsequent tasks and simply noting in the work plan that the scope of these activities will be refined at a later point in the process. This will reduce the time needed to prepare and review the initial work plan. As the RI/FS process progresses and a better understanding of the site is gained, these task descriptions can be refined. The preliminary definitions of tasks necessary to complete the RI/FS should be documented in the work plan and can be used as a basis for scheduling and estimating the RI/FS budget.

2.3.10 Identify Health and Safety Protocols

Protecting the health and safety of the investigative team and the general public is a major concern during remedial response actions. Workers

may be exposed to a variety of hazards including toxic chemicals, biological agents, radioactive materials, heat or other physical stresses, equipment-related injuries, and fires or explosions. The surrounding community may be at increased risk from unanticipated chemical releases, fires, or explosions created by onsite activities. In recognition of these concerns, OSHA has published regulations that stress the importance both of an underlying health and safety program and of site-specific safety planning. Appendix A provides an overview of the regulations pertaining to hazardous waste site workers and focuses on the requirements that employers, contractors, and subcontractors must meet when involved in remedial response actions.

2.3.11 Conduct Community Interviews

The community relations staff members, which can be either lead agency or contractor personnel and technical staff, should work together during the scoping process so that there is sufficient information to conduct community interviews. Community relations staff members then meet with the identified groups or individuals to gain an understanding of the site's history and the community's involvement with the site from the community's perspective. The lead agency will determine on a site-specific basis the type and number of interviews that need to be conducted to obtain sufficient information to develop an effective community relations plan. The results of the interviews should be made available to all technical staff members to assist in identifying potential waste types and disposal practices, potential pathways of contamination, and potential receptors. On the basis of an understanding of the issues and concerns of the community, the community relations history, and the citizens' indicated preferences for how they would like to be informed concerning site activities, the community relations plan is prepared. Plans should provide opportunities for public input throughout the remedial planning process as appropriate.

2.4 DELIVERABLES AND COMMUNICATION

There are several points during the scoping process when communication is required between the lead agency and its contractor and/or the support

agency (see Table 2-2). It is especially important that discussion and information exchange occur if interim actions or limited field investigations are considered necessary. For all RI/FSs, it is desirable for the lead and support agencies and their contractors to review existing data and to concur on the major tasks to be conducted at a site. Specific guidance for the timing and nature of communications between the lead and support agencies is provided in the "Superfund Memorandum of Agreement Guidance" (in preparation).

Deliverables required for all RI/FSs in which field investigations are planned consist of a work plan, a sampling and analysis plan, a health and safety plan, and a community relations plan. Each of these plans is described below.

2.4.1 Work Plan

2.4.1.1 Purpose

The work plan documents the scoping process and presents anticipated future tasks. It also serves as a valuable tool for assigning responsibilities and setting the project's schedule and cost. Information on planning work for lead agency staff may be found in the Federal-Lead Remedial Project Management Handbook (U.S. EPA, December 1986); and the State-Lead Remedial Project Management Handbook (U.S. EPA, December 1986).

The work plan documents the decisions and evaluations made during the scoping process and is usually submitted in conjunction with the SAP, health and safety plan, and the community relations plan, although each plan may be delivered separately. The work plan should be modified as necessary throughout the RI/FS process to reflect changes in scope.

TABLE 2-2. COMMUNICATION AND DELIVERABLES REQUIRED DURING SCOPING

Information Needed	Purpose	Potential Methods of Information Exchange
If interim actions are needed	For lead agency and contractor to identify actions that will abate immediate threat to public health or prevent further degradation of the environment; obtain concurrence of support agency	Meeting Tech memo Other
If limited field investigations are needed	For lead agency and contractor to improve focus of RI and reduce time and cost; obtain concurrence of support agency	Meeting Tech Memo Other
Summary of existing data; need to conduct field studies prior to FS; identification of preliminary remedial action alternatives	For lead agency and contractor to confirm need for field studies; for lead agency and contractor to plan data collection; obtain support agency review and concurrence	Meeting Tech Memo Other
Document QA and field sampling procedures	For contractor to obtain lead agency review and approval; for lead agency to obtain support agency review and comment	SAP (FSP,QAPP)
Document health and safety procedures	For contractor to obtain lead agency agreement that OSHA safety requirements are met	Health and safety plan
Document all RI/FS tasks	For contractor to obtain lead agency review and approval; for lead agency to obtain support agency concurrence	Work plan

The primary user of the RI/FS work plan is the lead agency for the site (usually either the EPA Region or the appropriate State agency) and the project team that will execute the work. Secondary users of the work plan include other groups or agencies serving in a review capacity, such as EPA Headquarters and local government agencies. In enforcement cases, PRPs may also review and comment on the work plan. It should also be noted that the work plan is usually made available for public comment (often in conjunction with a public meeting) and is placed in the Administrative Record.

2.4.1.2 Preparation

The work plan presents the initial evaluation of existing data and background information performed during the scoping process, including the following:

- An analysis and summary of site background and physical setting
- An analysis and summary of previous response actions
- Presentation of the conceptual site model, including an analysis and summary of the nature and extent of contamination; preliminary assessment of public health and environmental impacts; and the additional data needed to conduct the baseline risk assessment
- Preliminary identification of general response actions and alternatives and the data needed for the evaluation of alternatives

The work plan also defines the scope and objectives of RI/FS activities to the extent possible.

The scope of the RI site characterization should be documented in the work plan, with detailed descriptions provided in the SAP. Later tasks will usually be scoped in less detail, pending the acquisition of more complete data about the site.

The initial work plan is prepared prior to the RI site characterization. Because the RI/FS process is dynamic and iterative, the work plan or supplemental plans, such as the QAPP and the FSP, can be modified during the RI/FS process to incorporate new information and refined project objectives. The work plan should be revised, if necessary, before (1) additional iterations of site characterization activities, and (2) treatability investigations.

2.4.1.3 Work Plan Elements

Five elements typically are included in a work plan. They are described in Appendix B.

Among the elements to be included is the specification of RI/FS tasks. For Federal-lead sites, 15 standard tasks have been defined to provide consistent reporting and allow more effective monitoring of RI/FS projects. Figure 2-4 shows these tasks and their relationship to the phases of an RI/FS, and detailed task definitions are included in Appendix B. RI/FSs that are not Federal-lead projects do not need to use these standard tasks, but the use of these tasks provides a project management tool and allows historical cost and schedule data to help estimate these factors in project planning and management.

Project Management Considerations. Project management considerations may be specified in the work plan to define relationships and responsibilities for selected task and project management items. This specification is particularly useful when the lead agency is using extensive contractor assistance. The following project management considerations may be discussed in the work plan:

- Identification of staff (the lead agency's RPM, the contractor, the contractor's site manager, and other team members)

- Coordination among the lead agency, the support agency, and their contractors

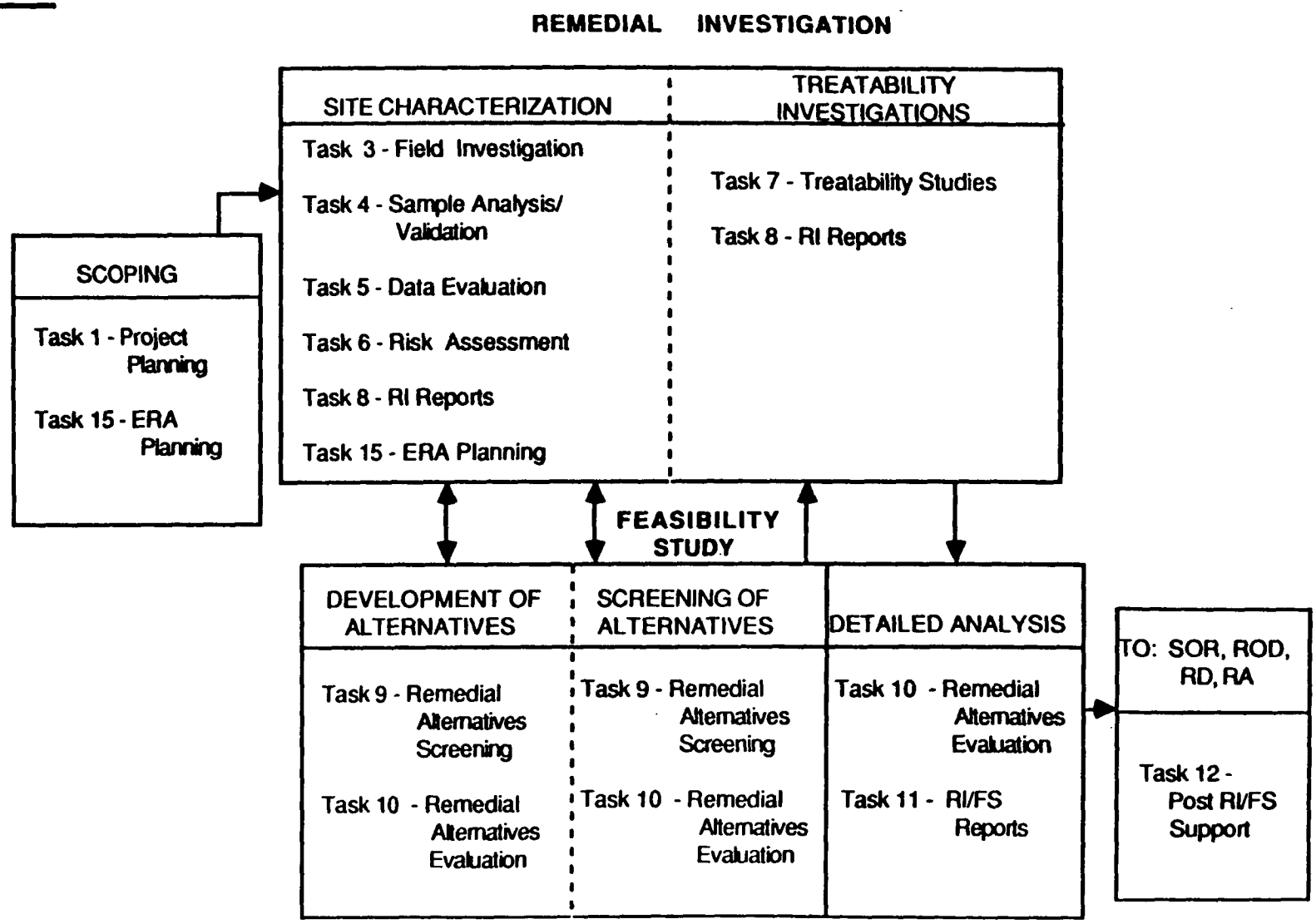
FIGURE 2-4

RELATIONSHIP OF RI/FS TASKS TO PHASED RI/FS APPROACH

RI/FS WORK PLAN STANDARD TASKS

TASK	TITLE
1	Project Planning
2	Community Relations *
3	Field Investigation
4	Sample Analysis/ Validation
5	Data Evaluation
6	Risk Assessment
7	Treatability Study/ Pilot Testing
8	Remedial Investigation Reports
9	Remedial Alternatives Screening
10	Remedial Alternatives Evaluation
11	Feasibility Study (RI/FS) Reports
12	Post RI/FS Support
13	Enforcement Support *
14	Miscellaneous Support *
15	ERA Planning

* Tasks that can occur in any Phase of the RI/FS



- Coordination with other agencies (Typically, the lead agency's RPM is the focus for the coordination of all other agency and private participation in site activities and decisions.)

- Coordination of subcontractors, if any, and description of health and safety requirements and responsibilities

- Interface for Federal-lead projects with the Contract Laboratory Program (CLP), if needed, to minimize sampling requirements by use of field screening, to schedule analyses well ahead of sampling trips, and to accurately complete CLP paperwork

- Cost control (including a description of procedures for contractors to report expenditures)

- Schedule control (including a description of schedule tracking methods and procedures for contractors to report activities to the lead agency)

- Identification of potential problems so that the RPM and site manager can develop contingency plans for resolution of problems during the RI/FS

- Evidentiary considerations, if needed, to ensure that project staff members are trained with regard to requirements for admissibility of the work in court

Cost and Key Assumptions. For Federal-lead sites, the RI/FS work plan includes a detailed summary of projected labor and expense costs, broken down by the 15 tasks listed in Figure 2-3 and described in Appendix B, and a description of the key assumptions required to make such a cost estimate. During scoping, more detailed costs typically are provided for the RI site characterization tasks than for later phases of the RI/FS. The less-detailed costs may be refined as field investigations progress and the

nature and extent of site contamination is more fully understood. Cost estimates may not be required for State- and PRP-lead RI/FSs.

RI/FS costs vary greatly among sites and are influenced by the following:

- The adequacy of existing data
- The size and complexity of the site
- The level of personnel protection required for onsite workers
- The number and depth of wells required and the types of subsurface conditions where wells will be installed
- The number and types of media sampled
- The number of samples per media required
- The need for support of enforcement activities
- The need for bench- or pilot-scale tests

Schedule. The anticipated schedule for the RI/FS is formulated on the basis of the scope of the project, including the identification of key activities and deliverable dates. As with cost, the scheduling of tasks varies among sites.

2.4.1.4 Report Format

The work plan should include the elements described in Appendix B. Table 2-3 gives a suggested format.

TABLE 2-3. SUGGESTED RI/FS WORK PLAN FORMAT

Executive Summary

1. Introduction

2. Site Background and Setting

3. Initial Evaluation

   - Types and volumes of waste present
   - Potential pathways of contaminant migration/preliminary public health and environmental impacts
   - Preliminary identification of operable units
   - Preliminary identification of response objectives and remedial action alternatives

4. Work Plan Rationale

   - DQO needs
   - Work plan approach

5. RI/FS Tasks

6. Costs and Key Assumptions

7. Schedule

8. Project Management

   - Staffing
   - Coordination

9. References

Appendixes

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2.4.2 Sampling and Analysis Plan (SAP)

2.4.2.1 Purpose

The SAP consists of two parts: (1) a quality assurance project plan (QAPP) that describes the policy, organization, functional activities, and quality assurance and quality control protocols necessary to achieve DQOs dictated by the intended use of the data; and (2) the field sampling plan (FSP) that provides guidance for all fieldwork by defining in detail the sampling and data-gathering methods to be used on a project. The FSP should be written so that a field sampling team unfamiliar with the site would be able to gather the samples and field information required. Guidance for the selection and definition of field methods, sampling procedures, and custody can be acquired from the Compendium of Superfund Field Operations Method (EPA/540/P-87/001a, OSWER Directive 9355.0-14, September 1987). To the extent possible, procedures from A Compendium of Superfund Field Operations Methods should be incorporated by reference. In addition, the QAPP and FSP should be submitted as a single document (although they may be bound separately to facilitate use of the FSP in the field). These efforts will streamline preparation of the document and reduce the time required for review.

The purpose of the SAP is to ensure that sampling data collection activities will be comparable to and compatible with previous data collection activities performed at the site while providing a mechanism for planning and approving field activities. The plan also serves as a basis for estimating costs of field efforts for inclusion in the work plan.

2.4.2.2 Plan Preparation and Responsibilities

Timing. A SAP is prepared for all field activities. Initial preparation takes place before any field activities begin, but the SAP may be amended or revised several times during the RI site characterization or treatability post-screening investigations or during the FS as the need for field activities is reassessed and rescoped.

Preparation and Review. EPA, the states, or the contractors should prepare SAPs for all field activities performed. The lead agency's project officer must approve the SAP. Signatures on the title page of the plan usually show completion of reviews and approvals. Environmental sampling should not be initiated until the SAP has received the necessary approvals. A suggested format for a SAP is listed in Table 2-4.

2.4.2.3 Quality Assurance Project Plan Elements

Every QAPP should contain 14 elements. These are listed in Table 2-4 and described in detail in Appendix B.

It is important to note that the required information for each of the elements of a QAPP need not be generated each time a QAPP is prepared. Only those aspects of a QAPP that are specific to the site being investigated need to be explicitly described. If site-specific information is already contained in another document (e.g., the FSP) it need only be referenced. Similarly, any information contained in guidance documents such as the DQO Guidance should only be referenced and not repeated in the QAPP.

2.4.2.4 Field Sampling Plan Elements

The second part of the SAP is the FSP. The FSP consists of the six elements contained in Table 2-4. These elements are described more fully in Appendix B.

2.4.3 Health and Safety Plan

2.4.3.1 Purpose

Each remedial response plan will vary as to degree of planning, special training, supervision, and protective equipment needed. The health and safety plan prepared to support the field effort must conform to the firm's or agency's health and safety program which must be in compliance with OSHA.

TABLE 2-4. SUGGESTED FORMAT FOR SAP (QAPP AND FSP)

QAPP

Title Page

Table of Contents

1. Project Description
2. Project Organization and Responsibilities
3. QA Objectives for Measurement
4. Sampling Procedures
5. Sample Custody
6. Calibration Procedures
7. Analytical Procedures
8. Data Reduction, Validation, and Reporting
9. Internal Quality Control
10. Performance and Systems Audits
11. Preventative Maintenance
12. Data Assessment Procedures
13. Corrective Actions
14. Quality Assurance Reports

FSP

1. Site Background (if not included in QAPP)
2. Sampling Objectives
3. Sample Location and Frequency
4. Sample Designation
5. Sampling Equipment and Procedures
6. Sample Handling and Analysis

The site health and safety plan should be prepared concurrently with the sampling plan to identify potential problems early, such as the availability of adequately trained personnel and equipment. The plan should include maps and a detailed site description, results of previous sampling activities, and field reports. The plan preparer should review site information, along with proposed activities, and use professional judgment to identify potentially hazardous operations and exposures and prescribe appropriate protective measures. Appendix B of the NIOSH/OSHA/USCG/USEPA Guidance Manual (1985) provides an example of a generic format for a site health and safety plan that could be tailored to the needs of a specific employer or site; the elements required in a site health and safety plan are listed in 29 CFR 1910.120.

2.4.3.2 Elements of the Health and Safety Plan

Each site health and safety plan should include, at a minimum, the 11 elements described in Appendix B.

2.4.3.3 Site Briefings and Inspections

The OSHA regulation requires that safety briefings be held "prior to initiating any site activity and at such other times as necessary to ensure that employees are apprised of the site safety plan and that it is being followed."

The final component of site health and safety planning or informational programs is site auditing to evaluate compliance with and effectiveness of the site health and safety plan. The site health and safety officer or that person's designee should carry out the inspections.

2.4.4 Community Relations Plan

2.4.4.1 Purpose

The community relations plan (CRP) documents the community relations history and the issues of community concern. It should describe the techniques that will be employed needed to achieve the objectives of the program. The plan is used by community relations staff, but it should also be used by Federal and State agency technical staff members when planning technical work at the site.

2.4.4.2 Community Relations Plan Elements

Report preparation methods, the elements contained in a CRP, and a recommended format are included in Community Relations in Superfund: A Handbook (U.S. EPA, January 1986). This handbook also includes useful examples of community relations plans.

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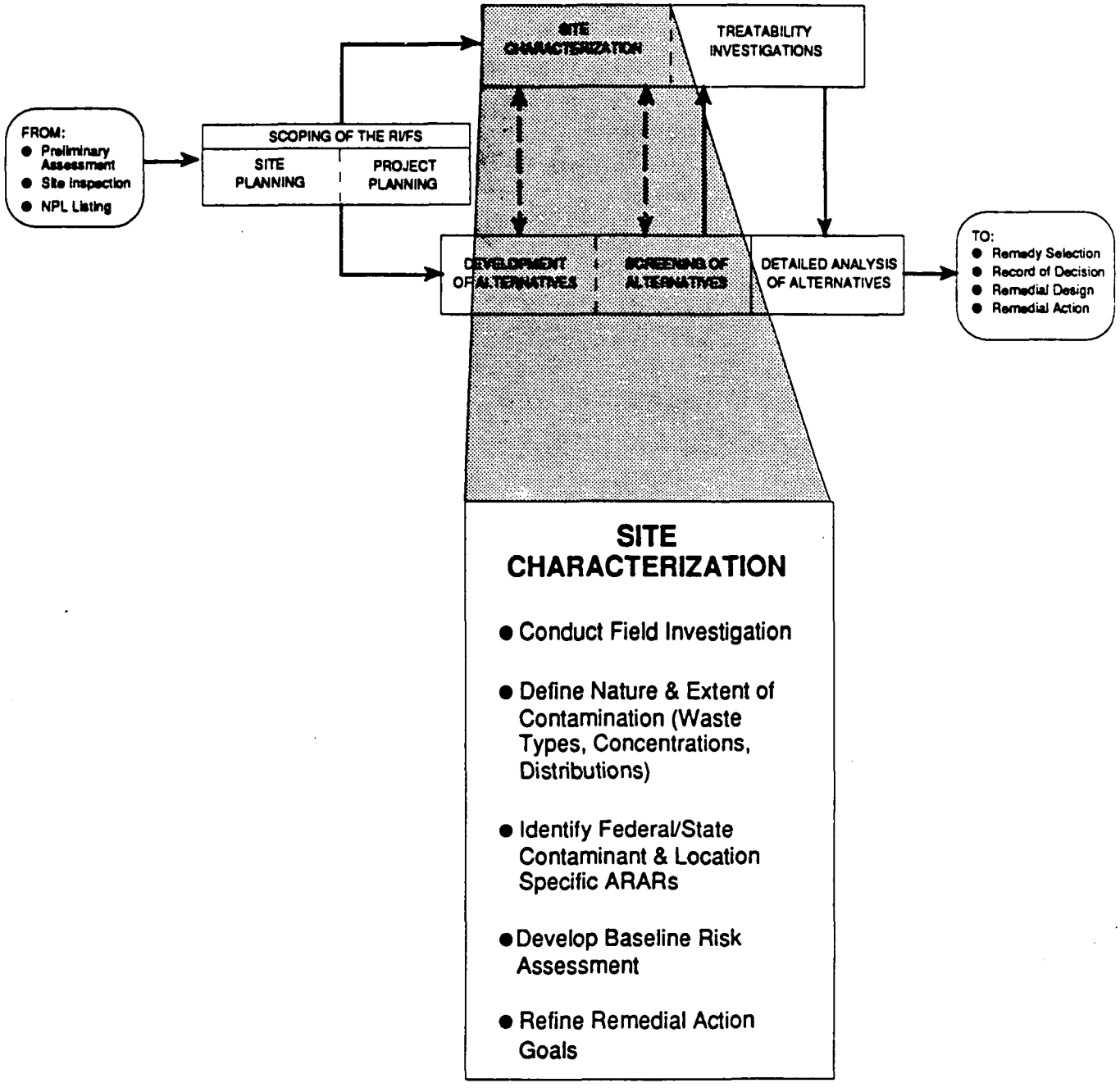
CHAPTER 3
SITE CHARACTERIZATION



CHAPTER 3
SITE CHARACTERIZATION

3.1 INTRODUCTION

During site characterization, the sampling and analysis plan (SAP) developed during project planning is implemented and field data are collected and analyzed to determine to what extent a site poses a threat to human health or the environment. The major components of site characterization are presented in Figure 3-1 and include:

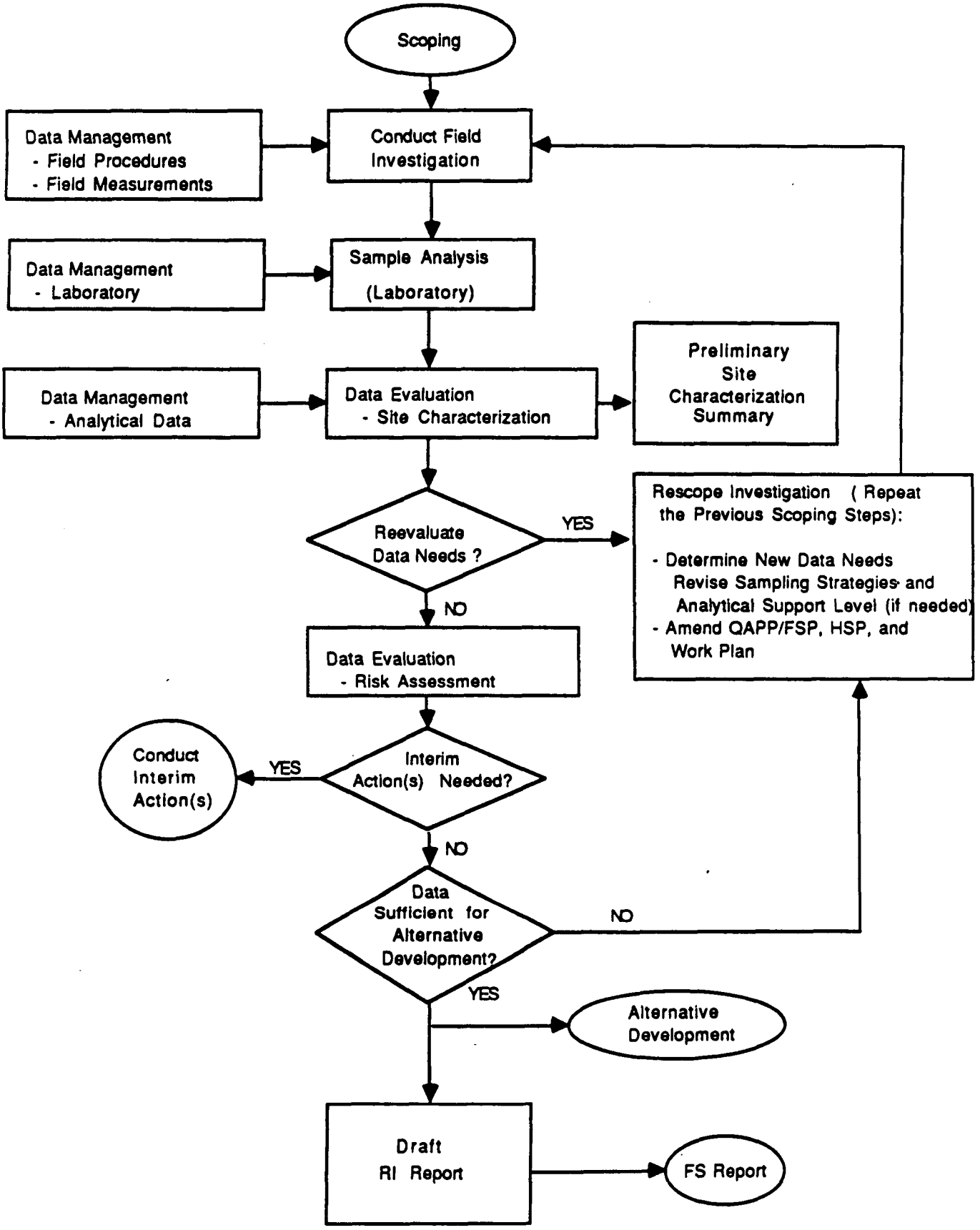
- Conducting field investigations as appropriate
- Analyzing field samples in the laboratory
- Evaluating results of data analysis to characterize the site and develop a baseline risk assessment
- Determining if data are sufficient for developing and evaluating potential remedial alternatives

Because information on a site may be limited prior to conducting an RI, it is often desirable to conduct two or more iterative field investigations so that sampling efforts can be better focused. Furthermore, as remedial alternatives are assembled, screened, and evaluated, the need for more field studies may be identified. As a result, rescoping can occur at several points in the RI/FS process. During site characterization, rescoping and additional sampling may occur if the results of field screening or onsite laboratory analyses show that site conditions are significantly different than believed during site and project planning. In addition, once the sample analytical results have been received (either from a laboratory or

FIGURE 3-1

OSWER Directive 9355.3-01

MAJOR COMPONENTS OF SITE CHARACTERIZATION



a mobile lab) and the data analyzed, it must be decided if further sampling is needed to support the FS or if data are sufficient to assess risks and initiate the development of alternatives. At this time, it is usually apparent whether the data needs identified during project planning were adequate and whether those needs were satisfied by the first round of field sampling. As discussed in Chapters 4 and 5, there are also points during the FS when the need for additional field studies may be identified. These additional studies can be conducted during subsequent site characterization activities.

To facilitate ATSDR's health assessment of a site, the lead agency should provide data obtained during site characterization to ATSDR for its use in conducting a health assessment. Guidance for coordinating remedial and ATSDR health assessment activities is provided in OSWER Directive 9285.4-02. The lead agency is also responsible for providing information to the support agency on the types of contaminants and affected media for identification of State (for a Federal-lead site) or Federal (for a State-lead site) ARARs.

This chapter provides detailed descriptions of those activities that may be required during the RI site characterization. As discussed earlier, the complexity and extent of potential risks posed by Superfund sites is highly variable. Therefore, the lead and support agencies will have to decide on a site-specific basis which of the activities described in this chapter must be conducted to adequately characterize the problem(s) and help in the evaluation of potential alternatives.

3.2 FIELD INVESTIGATION METHODS

Field investigation methods employed in RIs are selected to meet the data needs established in the scoping process and outlined in the work plan and SAP. This section provides an overview of the type of site characterization data that may be required and the investigative methods used in obtaining these data. The following sections describe methods for (1) implementing field activities, (2) investigating site physical characteristics, (3) defining the sources of contamination, and (4) determining the nature and extent

of contamination. Specific information on the field investigation methods described below is contained in A Compendium of Superfund Field Operations Methods (EPA/540/P-87/001a, OSWER Directive 9355.0-14, September 1987). Sections in A Compendium of Superfund Field Operations Methods that apply to particular types of field investigations are shown in Table 3-1.

3.2.1 Implement Field Activities

In addition to development of the SAP, fieldwork support activities, such as the following, are often necessary before beginning fieldwork:

- Assurance that access to the site and any other area to be investigated has been obtained
- Procurement of subcontractors such as drillers, excavators, surveyors, and geophysicists
- Procurement of equipment (personal protective ensembles, air monitoring devices, sampling equipment, decontamination apparatus) and supplies (disposables, tape, notebook, etc.)
- Coordination with analytical laboratories, including sample scheduling, reporting, chain-of-custody records, and sample bottle acquisition and procurement of close support laboratories or other in-field analytical capabilities
- Procurement of onsite facilities for office space, onsite laboratory, decontamination, equipment and vehicle maintenance and repair, and sample storage, as well as onsite water, electric, telephone, and sanitary utilities
- Provisions for storage or disposal of contaminated material (e.g., decontamination solutions, disposable equipment, drilling muds and cuttings, well-development fluids, well-purging water, and spill-contaminated materials)

Table 3-1
RELATIONSHIP AMONG SITE CHARACTERIZATION TASKS
AND THE COMPENDIUM

Tasks	Applicable Sections and Subsections of the Compendium of Superfund Field Operations Methods
Field Investigation	
Air	7, 11, 15
Biota	12
Close support laboratories	5.2, 7, 15
RI-derived waste disposal	3.2, 5.2.6.4, 8.1.6.3
Soil gas	
Support	3, 17, 18, 19, 20
Well logging	8.1, 8.3
Mapping and survey	14
Geophysical	8.4
Well installation	8.1, 8.5
Ground water	8.5
Soil	8.1, 8.2, 8.3
Source testing	7, 13, 15
Surface water	10
Sample analysis	
Fieldwork, close support laboratory	5.2, 15
Data validations	16
Sample management	4, 5, 6
Data evaluation	16

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Since procurement activities can take up to several months, they should be initiated as early as possible so as not to affect the overall RI/FS schedule. Schedule impacts should also be avoided by structuring contracts, where possible, such that there is no need to reprocure services for subsequent site characterization activities. This may be accomplished using contract options that are exercised only in the event that additional services or facilities are required.

Mobile labs or labs located near the site can often reduce the time necessary for completing RI activities. If such quick-turnaround analysis is available, it can be used to determine the location and type of subsequent sampling that must take place to more completely characterize the site. This may also alleviate the need to reprocure subcontractors, and significantly accelerate the completion of the RI. It is important to note that if such analytical techniques are to be employed, the work plan and SAP should allow for decisions on subsequent activities to be made in the field with verbal approval from key management personnel.

3.2.2 Investigate of Site Physical Characteristics

Data on the physical characteristics of the site and surrounding areas should be collected to the extent necessary to define potential transport pathways and receptor populations and to provide sufficient engineering data for development and screening of remedial action alternatives. Information normally needed can be categorized as surface features (including natural and artificial features), geology, soils, surface water hydrology, hydrogeology, meteorology, human populations, and land uses and ecology.

3.2.2.1 Surface Features

Surface features may include facility dimensions and locations (buildings, tanks, piping, etc.), surface disposal areas, fencing, property lines and utility lines, roadways and railways, drainage ditches, leachate springs, surface-water bodies, vegetation, topography, residences, and

commercial buildings. Features such as these are usually identified for contaminant migration and the location of potentially affected receptors.

Investigation of surface features should not be limited to those that are onsite, but should include significant offsite features as well. Other facilities in the area that are potential contributors to contamination should also be identified.

A history of surface features at the site can be developed from existing data. As discussed in Chapter 2, "Scoping," the data may include historical photographs, past topographic surveys, operational records, and information obtained during interviews with owners, operators, local residents, and local regulatory agencies. Review of historical photographs is sometimes the most valuable of these methods. Aerial photographs are often available from such sources as the Environmental Monitoring Support Laboratory, Las Vegas (EMSL-LV), the Environmental Photographic Intrepretation Center (EPIC), and the Soil Conservation Service of the USDA.

Existing surface features may be described using aerial photography, surveying and mapping, and site inspection. Inspection of the site and the surrounding areas is normally augmented with photographs. Section 14 of A Compendium of Superfund Field Operations Methods presents additional details on land surveying, aerial photography, and mapping.

3.2.2.2 Geology

Geology may control or affect the following aspects of a site:

- The depths, locations, and extents of water-bearing units or aquifers
- The release of contaminants and subsequent movement through the environment

- The engineering geologic aspects of site exploration and remediation

Table 3-2 summarizes detailed aspects of site geology. The investigation of site geology must be tailored to ensure identification of those aspects that will affect the fate and transport of contaminants. For example, an understanding of site geology is less important at a site at which release of contaminants occurs by volatilization to the atmosphere than at a site at which contaminants are moving toward the water table.

To understand the geology of a site, one must determine the geology of bedrock and of unconsolidated overburden and soil deposits. Table 3-1 summarizes specific aspects of overburden and bedrock geology. The degrees to which overburden and bedrock geology must be understood depend on the geologic character of the site area, as well as on the physical characteristics of the site itself. An understanding of the regional geologic character of a site is useful in determining which aspect of site geology may have the greatest influence on the determination of the fate and transport of contaminants and on the use of potential remedial technologies.

In general, an investigation of site geology should include the following steps:

- Determination of regional geology from available information

- Reconnaissance mapping of the area, which may include geophysical investigations onsite

- Subsurface explorations

The degree to which these steps are undertaken will be determined by the degree to which the need to evaluate geologic aspects of the site dictates the investigations needed in the RI/FS process. Table 3-2 discusses these investigation methods, and the methods are described in detail in Chapter 8 of A Compendium of Superfund Field Operations Methods.

Table 3-2
SUMMARY OF SITE GEOLOGY

Information Needed	Purpose or Rationale	Collection Methods
o Geology of unconsolidated overburden and soil deposits - Thickness and areal extent of units - Lithology; mineralogy - Particle size and sorting; porosity o Geology of bedrock - Type of bedrock (igneous, metamorphic, sedimentary) - Lithology; petrology - Structure (folds, faults) - Discontinuities (joints, fractures, bedding planes, foliation) - Unusual features such as igneous intrusive bodies (dikes), lava tubes, solution cavities in limestone (Karst)	For both unconsolidated and bedrock geology: o Evaluate the influence of geology on water-bearing units and aquifers o Evaluate the influence of geology on release and movement of contaminants o Obtain information on the engineering geologic aspects of site remediation	For both unconsolidated and bedrock geology: o Determination of regional geology from available information - Published reports (geologic reports, ground-water reports, soil survey reports) - State geologic maps - USGS topographic quadrangle maps - Descriptions of regional geology from previous reports of site investigations o Site reconnaissance mapping - Field mapping of surficial soil and overburden units, bedrock outcrops, surface water drainage, springs, and seeps - Analyses of aerial photography or other remote imagery - Surface geophysics o Subsurface explorations - Test borings or core borings (with or without sampling) - Test pits and trenches - Description and logging of subsurface geologic materials - Sample collection for laboratory analyses of physical properties and mineral content - Borehole geophysics

3.2.2.3 Soils and the Vadose Zone

Properties of surface soils and the vadose zone influence the type and rate of contaminant movement to the subsurface and subsequently to the water table. Contaminants that can move through the surface soil and into the vadose zone may move directly to the water table or they may be partially or fully retained within the vadose zone to act as continual sources of groundwater contamination. Engineering, physical, and chemical properties of soil and vadose zone materials can be measured in the field or in the laboratory. Table 3-3 summarizes typical investigation methods.

3.2.2.4 Surface-Water Hydrology

Surface-water features may include erosion patterns and surface-water bodies such as ditches, streams, ponds, and lakes. The transport of contaminants in surface-water bodies is largely controlled by flow, which in streams is a function of the gradient, geometry, and coefficient of friction. A description of how flow is measured can be found in Section 10 of A Compendium of Superfund Field Operations Methods. Contaminants have three possible modes of transport: (1) sorption onto the sediment carried by the flow, (2) transport as suspended solid, and (3) transport as a solute (dissolved). The transport of dissolved contaminants, which move the fastest, can be determined by characterizing the flow of the surface water and the contaminant dispersion. Sediment and suspended solid transport involve other processes such as deposition and resuspension. Table 3-4 presents the surface-water information that may be required for RIs.

If potential pathways include surface water, necessary data about impoundments may include (1) physical dimensions such as depth, area, and volume; (2) residence time; and (3) current direction and rates. As with impoundments, the direction and velocity of lake currents are often highly variable and, as a result, are difficult to measure and accurately predict. Site mapping will provide much of this information. Measurement techniques, which are specified in Section 10, Surface Hydrology, of A Compendium of Superfund Field Operations Methods, include the use of current meters and drogue tracking.

Table 3-3
SUMMARY OF SOIL AND VADOSE ZONE INFORMATION

Potential Information Needed	Purpose or Rationale	Collection Methods: Primary	Collection Methods: Secondary
Soil Characteristics:			
Type, holding capacity, temperature, biological activity, engineering properties	Estimate the effect of the properties on infiltration and retardation of leachates and the release of gaseous contaminants	Reports and maps by Federal and county agencies, Soil Conservation (SCS) publications	Borehole sampling, laboratory measurements (ASTM methods), water budget methods, instantaneous rate method, seepage meters, infiltrometers, test basins
Soil Chemistry Characteristics:			
Solubility, ion speciation, adsorption coefficients, leachability, cation exchange capacity, mineral partition coefficients, chemical and sorptive properties	Predict contaminant movement through soils and availability of contaminants to biological systems	Existing scientific literature	Chemical analysis, column experiments, leaching tests
Vadose Zone Characteristics:			
Permeability, variability, porosity, moisture content, chemical characteristics, extent of contamination	o Estimate flux in the vadose zone	Existing literature	Water budget with soil moisture accounting Draining profile methods Measurement of hydraulic gradients Estimates assuming unit hydraulic gradient Flow meters Methods based on estimating or measuring hydraulic conductivity, using: o Laboratory parameters o Relationships between hydraulic conductivity and grain size o Catalog of hydraulic properties o Field measurements of hydraulic conductivity using single or multiple wells
	o Estimate velocity in the vadose zone	Existing literature	o Tracers o Calculations using flux values o Calculation using long-term infiltration data
	o Evaluate pollutant movement in the vadose zone	Existing literature	Four probe electrical method Electrical conductivity probe Salinity sensors Solids sampling followed by laboratory extraction of pore water Solids sampling for organic and microbial constituents Suction Lysimeters Sampling perched ground water

Table 3-4
SUMMARY OF SURFACE-WATER INFORMATION THAT MAY BE IMPORTANT TO SITE CHARACTERIZATION

Information Needed	Purpose or Rationale	Appropriate Collection Methods	
		Primary	Secondary
Drainage Patterns:			
o Overland flow, topography, channel flow pattern, tributary relationships, soil erosions, and sediment transport and deposition	Determine if overland or channel flow can result in onsite or offsite flow and if patterns form contaminant pathways	Topographic maps, site inspection, and soil conservation services	Aerial mapping, and ground survey
Surface-Water Bodies:			
o Flow, stream widths and depths, channel elevations, flooding tendencies, and physical dimensions of surface-water impoundments	Determine volume and velocity, transport times, dilution potential, and potential spread of contamination	Public agency data and atlases; catalogs, maps, and handbooks for background data	Aerial mapping, and ground survey
o Structures	Effect of manmade structures on contaminant transport and mitigation	Public agency maps and records and ground survey	
o Surface-water/ground-water relationships	Predict contaminant pathways for interceptive remedial actions	Public agency reports and surveys	Water level measurements, and modeling
Surface-Water Quality:			
o pH, temperature, total suspended solids, suspended sediment, salinity, and specific contaminant concentrations	Provide capacity of water to carry contaminants and water/sediment partitioning	Public agency computerized data files, handbooks, and open literature	Sampling and analysis

3.2.2.5 Hydrogeology

Determination of site hydrogeology involves identification of geologic aspects, hydraulic properties, and ground-water use, as defined in Tables 3-5 and 3-6 and described in Chapter 8 of A Compendium of Superfund Field Operations Methods. The determination of site geology and hydrogeology can often be incorporated into a single investigative program. Regional hydrogeologic conditions can be determined from existing information; site-specific hydrogeologic conditions can be determined using subsurface explorations, well installations, and field testing of hydraulic properties. Table 3-7 summarizes the typical data collected during a hydrogeologic investigation and available analytical methodologies.

3.2.2.6 Meteorology

Meteorological data are often required to characterize the atmospheric transport of contaminants for risk assessment determinations and provide real-time monitoring for health and safety issues. Representative offsite and site-specific data may be obtained using sampling methods outlined in Section 11, "Meteorology and Air Quality," of A Compendium of Superfund Field Operations Methods. This publication also discusses data requirements for using refined air quality modeling and applicable models. Table 3-8 summarizes atmospheric investigations.

3.2.2.7 Human Populations

Information should be collected to identify, enumerate, and characterize human populations potentially exposed to contaminants released from a site. For a potentially exposed population, information should be collected on population size and location. Special consideration may be given to identifying potentially sensitive subpopulations such as children, pregnant women, infants, and the chronically ill. The identification of these high-risk subpopulations should be linked with the potential contaminants of concern (i.e., those that are mutagenic, teratogenic, etc.)

Table 3-5
ASPECTS OF SITE HYDROGEOLOGY

- Geologic aspects
  - Type of water-bearing unit or aquifer (overburden, bedrock)
  - Thickness, areal extent of water-bearing units and aquifers
  - Type of porosity (primary, such as intergranular pore space, or secondary, such as bedrock discontinuities or solution cavities)
  - Presence or absence of impermeable units or confining layers
  - Depths to water table; thickness of vadose zone
- Hydraulic aspects
  - Hydraulic properties of water-bearing unit or aquifer (hydraulic conductivity, transmissivity, storativity, porosity, dispersivity)
  - Pressure conditions (confined, unconfined, leaky confined)
  - Ground-water flow directions (hydraulic gradients, both horizontal and vertical), volumes (specific discharge), rate (average linear velocity)
  - Recharge and discharge areas
  - Ground-water or surface water interactions; areas of ground-water discharge to surface water
  - Seasonal variations of ground-water conditions
- Ground-water use aspects
  - Identify existing or potential aquifers
  - Determine existing near-site use of ground water

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Table 3-6
FEATURES OF GROUND-WATER SYSTEMS

- Components of the ground-water system
  - Unconfined aquifers
  - Confining beds
  - Confined aquifers
  - Presence and arrangement of components
- Water-bearing openings of the dominant aquifer
  - Primary openings
  - Secondary openings
- Storage and transmission characteristics of the dominant aquifer
  - Porosity
  - Transmissivity
- Recharge and discharge conditions of the dominant aquifer

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Table 3-7
SUMMARY OF IMPORTANT GROUND-WATER INFORMATION

Information Needed	Purpose or Rationale	Appropriate Collection Methods	
		Primary	Secondary*
Ground-Water Occurrence:			
o Aquifer boundaries and locations	Define flow limits and degree of aquifer confinement	Existing literature, water resource atlases	Installation of wells and piezometers (single level or multilevel)
o Aquifer ability to transmit water	Determine potential quantities and rates for treatment options	Pumping and injection tests of monitor wells	Ground-water level measurements (over time to monitor seasonal variations)
			Instrument survey of wells for calculation of ground-water elevations
			Borehole and surface geophysics
Ground-Water Movement:			
o Direction of flow	Identify most likely pathways of contaminant migration	Existing hydrologic literature	Water level measurements in monitor wells
			Testing of hydraulic properties using slug tests, tracer tests, and pump tests (short- or long-duration, single or multiple well)
			Elevation contours of water table or potentiometric surface
			Analytical calculations of flow directions and rates
			Computer generated simulations of ground-water flow and contaminant transport (using analytical or numerical methods)
			Generation of site water balance
o Rate of flow	Determine maximum potential migration rate and dispersion of contaminants	Existing hydrologic literature	Hydraulic gradient, permeability, and effective porosity from water level contours, pump test results, and laboratory analyses

*May be appropriate if detailed information is required or if it is the only method due to a paucity of published data.

Table 3-7 (continued)

Information Needed	Purpose or Rationale	Appropriate Collection Methods: Primary	Appropriate Collection Methods: Secondary*
Ground-Water Recharge/Discharge:			
o Location of recharge/ discharge areas	Determine interception points for withdrawal options or areas of capping	Existing site data, hydrologic literature, site inspection	Comparison of water levels in observation wells, piezometers, lakes, and streams Field mapping of ground-water recharge areas (losing streams, interstream areas) and ground-water discharge to surface water (gaining streams, seeps, and springs)
o Rate	Determine variability of loading to treatment options	Existing literature	Water-balance calculations aided by geology and soil data
Ground-Water Quality:			
o pH, total dissolved solids, salinity, specific contaminant concentrations	Determine exposure via ground water; define contaminant plume for evaluation of interception methods	Existing site data	Analysis of ground-water samples from observation wells, geophysics

*May be appropriate if detailed information is required or if it is the only method due to a paucity of published data.

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Table 3-8
SUMMARY OF IMPORTANT ATMOSPHERIC INFORMATION

Information Needed	Purpose or Rationale	Appropriate Collection Methods	
		Primary	Secondary
Local Climate: o Precipitation o Temperature o Wind speed and direction o Presence of inversion layers	Define recharge, aeolian erosion, evaporation potential, effect of weather patterns on remedial actions, area of deposition of particulates	National Climate Center (NCC) of National Oceanic and Atmospheric Administration; local weather bureaus	Onsite measurements and observations
Weather Extremes: o Storms o Floods o Winds	Determine effect of weather extremes on selection and timing of remedial actions, and extremes of depositional areas	NCC; State emergency planning offices; Federal Emergency Management Agency flood insurance studies	
Release Characteristics: o Direction and speed of plume movement o Rate, amount, temperature of release o Relative densities	Determine dispersion characteristics of release	Information from source facility, weather services, air monitoring services	Onsite measurements

to identify how these populations may be at risk. Census and other survey data may be used to identify and describe the population exposed to various contaminated media. Information may also be available from USGS maps, land use plans, zoning maps, and regional planning authorities.

Data describing the type and extent of human contact with contaminated media also are needed, including:

- o Location and use of surface waters
  - Drinking water intakes and distribution
  - Recreational (swimming, fishing) areas
  - Connection between surface-water bodies
- o Local use of ground water as a drinking-water source
  - Number of wells
  - Distance of wells from the site
  - Expected direction of ground-water flow
  - Depth of wells
  - Availability of alternate sources
- o Human use or access to the site and adjacent areas
  - Recreational use
  - Hunting
  - Fishing
  - Residential
  - Commercial
- o Location of population with respect to site
  - Proximity
  - Prevailing wind direction

Information on expected land use, as well as current land use, is desirable. Available population growth projections, land use plans, and zoning maps can help predict expected exposure scenarios. This information may be obtained from zoning boards, the census bureau, regional planning agencies, and other local governmental entities.

3.2.2.8 Ecological Investigations

Biological and ecological information collected for use in the risk assessment aids in the evaluation of impacts to the environment associated with a hazardous waste site and also helps to identify potential effects with regard to the implementation of remedial actions. The information should include a general identification of flora and fauna in and around the site (including endangered and threatened species and those consumed by humans or found in human food chains) and identification of critical habitats. Bioassay information may be needed for species that are known to be consumed by humans. Chapter 12 of A Compendium of Superfund Field Operations Methods and Table 3-9 provides a summary of both environmental information that may be needed and potential collection methods. The Natural Resources Trustee for the site should be contacted to determine if other ecological data are available that may be relevant to the investigation.

3.2.3 Define Sources of Contamination

Sources of contamination are often hazardous substances contained in drums, tanks, surface impoundments, waste piles, and landfills. In a practical sense, heavily contaminated media (such as soils) may also be considered sources of contamination, especially if the original source (such as a leaking tank) is no longer present on the site or is no longer releasing contaminants.

Source characterization involves the collection of data describing (1) facility characteristics that help to identify the source location, potential releases, and engineering characteristics that are important in the evaluation of remedial actions; (2) the waste characteristics, such as

Table 3-9
SUMMARY OF IMPORTANT ECOLOGICAL INFORMATION

Information Needed	Purpose or Rationale	Appropriate Collection Methods	
		Primary	Secondary
Fauna and Flora	Determine potentially affected ecosystems; determine presence of endangered species	Records of area plants and animals survey, survey of plants and animals on or near site; survey of site or area photographs	Ground surveys and sample collection
Critical Habitats	Determine area on or near site to be protected during remediation	Records of site environment	Ground survey
Land Use Characteristics	Determine if terrestrial environment could result in human exposure, e.g., presence of game animals, agricultural land	Agricultural and development maps; site survey	Ground and aerial survey
Water Use Characteristics	Determine if aquatic environment could result in human exposure, e.g., presence of game, fish, recreational water	Water resource agency reports; site surveys	
Biocontamination	Determine observable impact of contaminants on ecosystems	Records of site environment	Sampling and analysis

the type and quantity of contaminants that may be contained in or released to the environment; and (3) the physical or chemical characteristics of hazardous wastes present in the source. Key source characterization data are summarized in Table 3-10.

The location and type of containment should be determined for all sources. In addition, where the hazardous substance remains in containment vessels, the integrity of the containment structure should be determined so that the potential for release and its magnitude can be evaluated. This determination is especially important for buried drums or tanks, because corrosion may be rapid. These data, as well as the data identified in Table 3-10, may be obtained largely through site inspections, mapping, remote sensing, and sampling and analysis.

The waste type should be determined for each source. If available waste manifests or facility records can be reviewed, the industrial processes that resulted in generation of the waste can be determined and the types of contaminants usually present in the process waste can be identified. Often, sources are sampled and analyzed for contaminants found on the Target Compound List (TCL) (formerly the Hazardous Substances List) or other lists such as those developed for RCRA, as appropriate to the waste type. Quantities of wastes may be estimated for each waste type either from verifiable inventories of wastes, from sampling and analysis, or from physical dimensions of the source. Section 13 of the Compendium of Superfund Field Operations Methods and Ford, Turina, and Seely (1983) describe methods suitable for sampling and analysis.

It may be possible to determine the location and extent of sources and the variation of materials within a waste deposit by nonchemical analysis. Methodologies for this determination, which are described in Chapter 8 of the Compendium of Field Operations Methods, include geophysical surveys. A variety of survey techniques (e.g., ground-penetrating radar, electrical resistivity, electromagnetic induction, magnetometry, and seismic profiling), can effectively detect and map the location and extent of buried waste deposits. Aerial photography and infrared imagery can aid in defining sources

Table 3-10
SUMMARY OF IMPORTANT SOURCE INFORMATION

Information Typically Needed	Purpose or Rationale	Collection Methods	
		Primary	Secondary
Facility Characteristics:			
o Source location	Locate above-ground and subsurface contaminant sources	Site inspection facility records, archival photos	Remote sensing, sampling, and analysis
o Type of waste/chemical containment	Determine potential remedies for releases	Site inspection	Remote sensing
o Integrity of waste/chemical containment	Determine probability of release and timing of response	Site inspection	Sampling and analysis; nondestructive testing
o Drainage control	Determine probability of release to surface water	Site inspection; topographic maps	
o Engineeered structures	Identify possible conduits for migration or interference with remedial actions	Site inspection; facility records	Remote sensing
o Site security	Determine potential for exposure by direct contact; may dictate response	Site inspection	
o Known discharge points (outfalls, stacks)	Determine points of accidental or intentional discharge	Site inspection; facility records	

Table 3-10 (continued)

Information Typically Needed	Purpose or Rationale	Collection Methods	
		Primary	Secondary
o Mapping and surveying	Locate existing structures and obstructions for alternatives evaluation, site features, and topography	Existing maps (USGS, county, land development)	Remote sensing; surveying
Waste Characteristics:			
o Type	Determine contaminants for exposure assessments and for treatment options	Site inspection; waste manifests	Sampling and analysis
o Quantities	Determine magnitude of potential releases	Site inspection	Sampling and analysis; geophysical surveys
o Chemical and physical properties	Determine environmental mobility, persistence, and effects; determine parameters for development and evaluation of alternatives	Site inspection, handbooks, CHEMTREC/CHMTADS, Chemical Information Service (CIS), and facility records	Sampling and analysis
o Concentrations	Determine quantities and concentrations potentially released to environmental pathways	Site inspection	Sampling and analysis

through interpretation of the ecological effects that result from stressed biota. However, all of these geophysical methods are nonspecific, and subsequent sampling of the sources will probably be required to provide the data for evaluation of source control measures at the site.

3.2.4 Determine the Nature and Extent of Contamination

The final objective of the field investigations is to characterize the nature and extent of contamination. This process involves using the physical site characterization data (e.g., ground-water flow directions, overland flow patterns) to give a preliminary estimate of the locations of contaminants that may have migrated. An iterative monitoring program is then implemented so that, by using increasingly accurate analytical techniques, the locations and concentrations of contaminants that have migrated into the environment can be documented.

The sampling and analysis approach that should be used is discussed in Section 4.5.1 of the DQO Guidance. In short, the approach consists of, where appropriate, initially taking a large number of samples using field screening type techniques and then, based on the results of these samples, taking additional samples--to be analyzed more rigorously--from those locations that showed the highest concentrations in the previous round of sampling. The final step is to document the extent of contamination using an analytical level that yields data quality that is sufficient to serve as input to a risk assessment and to a subsequent analysis and selection of remedial alternatives.

At hazardous waste sites, the nature and extent of contamination is of concern in five media: ground water, soil, surface water, sediments, and air. The methodologies for conducting sampling and analysis for each of these media are discussed below. More detailed descriptions of the investigation process can be found in the DQO Guidance and A Compendium of Superfund Field Operations Methods.

3.2.4.1 Ground Water

The nature and extent of ground-water contamination must be determined in both the horizontal and vertical directions. On the basis of geologic and hydrogeologic investigations, it must be determined if contamination of an aquifer(s) is possible and if such contamination could potentially affect human or environmental receptors. Following this, a ground-water monitoring program should be implemented, concentrating the placement of wells in the direction of ground-water flow, in aquifers subject to contamination, and in places where they would indicate an existing or future threat to receptor populations. However, because of the uncertainties associated with subsurface migration, identifying background levels, and determining if there is a contribution from other sources, sampling should also be conducted in the area perceived to be upgradient from the contaminant source.

Because of the significant investment necessary to drill new wells and the resulting limited number of samples, neither Level I nor field-screening techniques are appropriate for analysis of ground water, other than to possibly better define chemical analysis parameters. Geophysical techniques can be useful in identifying the location of plumes and thereby assisting in the location of monitoring wells. However, geophysical techniques are subject to influences from external factors and are not appropriate at all sites. Therefore, care must be taken in employing these methods, and their results should always be confirmed with analytical sampling. Guidance on conducting ground-water sampling can be found in A Compendium of Superfund Field Operations Methods and the DQO Guidance.

3.2.4.2 Soil

As with ground-water sampling, the intent of soil sampling is to identify limits of existing soil contamination and characterize the contamination. However, whereas field-screening techniques can be inappropriate for ground-water sampling, these techniques are appropriate for directing soil sampling into areas of greatest contamination or "hot

spots." If existing information provides no basis for predicting where hot spots might occur, sampling locations can be chosen in a grid pattern of a size to ensure that investigators can be confident that areas of high concentration have been located. Often, especially if soil has been contaminated as a result of overland flow of contaminants from defined sources, sampling can be concentrated in those areas that, either through topography or evidence such as drainage channels, it is most likely that contaminants have been deposited.

As with ground water, soil contamination should be documented in both vertical and horizontal directions. This approach will help determine both areas of contamination and background concentrations. Soils to be analyzed usually can be obtained by hand, allowing many samples to be taken and initially analyzed with instruments such as a photoionization detector. Results of field screening can then be used to determine which samples should be further analyzed using more rigorous methods.

3.2.4.3 Surface Water

Leachate from contaminant sources or discharge of contaminated ground water can cause surface water to become contaminated. Surface-water sampling locations should be chosen at the perceived location(s) of contaminant entry to the surface water and downstream, as far as necessary, to document the extent of contamination. As with soil, the relative ease with which samples can be taken means that many samples can be taken and analyzed using field screening methods; then a subset of samples can be chosen for more rigorous analysis.

Contamination of surface water is sometimes the result of an incidental release of contaminants such as the overflowing or breach of a surface impoundment. In these cases, it is not likely that routine surface water sampling will show contamination that has or will occur. Therefore, to document whether such releases occur, sampling should be conducted during or following periods of heavy rainfall.

3.2.4.4 Sediments

A potentially more serious problem associated with the contamination of surface water by hazardous waste sites is contaminated sediments. Whereas contamination in surface water tends to become diluted or transformed as it travels downstream, contaminants deposited in sediments tend to remain in place and concentrate. It is therefore very important to monitor for sediment contamination if it is suspected that surface water has been contaminated.

The choice of sampling locations for sediments is similar to the criteria applied to surface-water sampling. Field-screening techniques can be useful in defining areas of contamination. However, it should be noted that sediment contamination often consists of inorganics and/or nonvolatile organics, for which field screening techniques are not as applicable. Therefore, in designing a sampling program, consideration of the contaminants of concern is very important.

3.2.4.5 Air

Volatilization of organics and emissions of airborne particulates can be a concern at hazardous waste sites. For sites at which it appears that air emissions may be a problem (e.g., surface impoundments containing volatile organics, landfills at which there is evidence of methane gas production and migration), an air emissions monitoring program should be undertaken. A field-screening program is recommended to determine if there is an air pollution problem, both for volatile organics and fugitive dust emissions. Because of the highly variable nature of air emissions from hazardous waste sites, consideration of meteorological conditions at the time of sampling is essential for the proper documentation of potential air pollution.

3.2.5 Additional Site Characterization

In some situations, additional site information may be required to refine our understanding of the site and better evaluate specific remedial alternatives. Examples include:

- Better delineation of contaminated areas and depths of contamination so that quantities of contaminated media to be processed can be calculated more accurately

- Characteristics of the media that would affect the feasibility of the remedial alternative, such as soil permeability for soil-vapor extraction

- Pertinent site characteristics not initially discovered in the initial site characterization process

Before additional site characterization is initiated, the most recent QAPP/FSP should be reviewed and modified as appropriate to guide the collection of additional site data. In addition, site data collected and evaluated as part of the initial RI site characterization should be reviewed and compared to the data needs identified for conducting the detailed analysis of alternatives. Reviewing data needs during the preplanning step is also useful in predicting the approximate characteristics of the samples to be collected.

3.3 LABORATORY ANALYSES

Data that will be used as the basis for decisionmaking requires that the analysis of samples in laboratories meets specific QA/QC requirements. To meet these requirements, Federal- or State-lead site investigations have the option of using mobile labs; the CLP, which is established by EPA; or a non-CLP laboratory that meets the data quality objectives of the site investigation.

The CLP provides analytical services through a nationwide network of laboratories under contract to EPA. The lead agency chooses whether or not to use a CLP laboratory on the basis of available CLP capacity and the analytical requirements that meet the data quality objectives. If the CLP is not used, a laboratory is procured using standard bidding procedures.

Under the CLP, the majority of analytical needs are met through standardized laboratory services provided by Routine Analytical Services (RAS). However, other specialized types of analysis not yet provided by standardized laboratory contracts may be scheduled on an as-needed basis under the Special Analytical Services (SAS) program. The RAS program currently provides laboratory services for the analysis of organics and inorganics in water or solid samples. The SAS program is designed to complement the RAS program by providing the capability for specialized or custom analytical requirements. If an analytical need is not ordinarily provided by RAS, a specific subcontract can be awarded under the SAS program to meet a particular requirement.

The decision whether to use mobile labs or a CLP or non-CLP laboratory should be based on several factors including the analytical services required, the number of samples to be analyzed, and anticipated turnaround time of the laboratory at the time samples are to be sent. Mobile or non-CLP labs located close to the site may be the best choice when fast turnaround of analytical results is required to meet specific sampling objectives or would result in a significant reduction of the overall RI/FS schedule. To facilitate the most efficient completion of the RI, mobile or non-CLP labs can be used to initially document the nature and extent of contamination. Selected duplicate samples can be sent to CLP labs to confirm and validate the analytical results from the mobile or non-CLP labs. This process assists in the timely completion of the RI and the initiation of FS activities, while still ensuring that legally defensible CLP data are available for decisionmaking and potential cost-recovery actions.

If a non-CLP laboratory is used, analytical protocols need to be specified in the bid packages sent to labs that are under consideration.

For Federal-lead sites, labs receiving invitations to bid have usually been approved by the EPA Regional QA representative. For State-lead sites at which non-CLP labs are used, the laboratory usually subcontracts with the prime contractor when the project is initiated.

Section 5 of A Compendium of Superfund Field Operations Methods presents the details of procedures for the use of CLP laboratories and non-CLP laboratories. The User's Guide to the Contract Laboratory Program also presents procedures for use of the CLP.

3.4 DATA ANALYSES

Analyses of the data collected should focus on the development or refinement of the conceptual site by presenting and analyzing data on source characteristics, the nature and extent of contamination, the contaminated transport pathways and fate, and the effects on human health and the environment. Data collection and analysis for the site characterization is complete when the DQOs that were developed in scoping (including any revisions during the RI) are met, when the need (or lack thereof) for remedial actions is documented, and when the data necessary for development, screening, and evaluation of remedial actions have been obtained. The presentation of data in the RI can be divided into an analysis of site characteristics and the baseline risk assessment.

3.4.1 Site Characteristics

The evaluation of site characteristics should define the current extent of contamination and estimate the travel time to, and the predicted contaminant concentrations at, potential exposure points. Data should be analyzed to describe (1) the site physical characteristics, (2) the source characteristics, (3) the nature and extent of contamination, and (4) the important contaminant fate and transport mechanisms.

3.4.1.1 Site Physical Characteristics

Data on site physical characteristics should be analyzed to describe the environmental setting at the site, including important surface features, soils, geology, hydrology, meteorology, and ecology. This analysis should emphasize factors important in determining contaminant fate and transport for those exposure pathways of concern. For example, if migration of contamination in ground water is of concern, these factors may include the properties of the unsaturated zone, the rate and direction of flow in the aquifer(s), and the extent of subsurface systems.

3.4.1.2 Source Characteristics

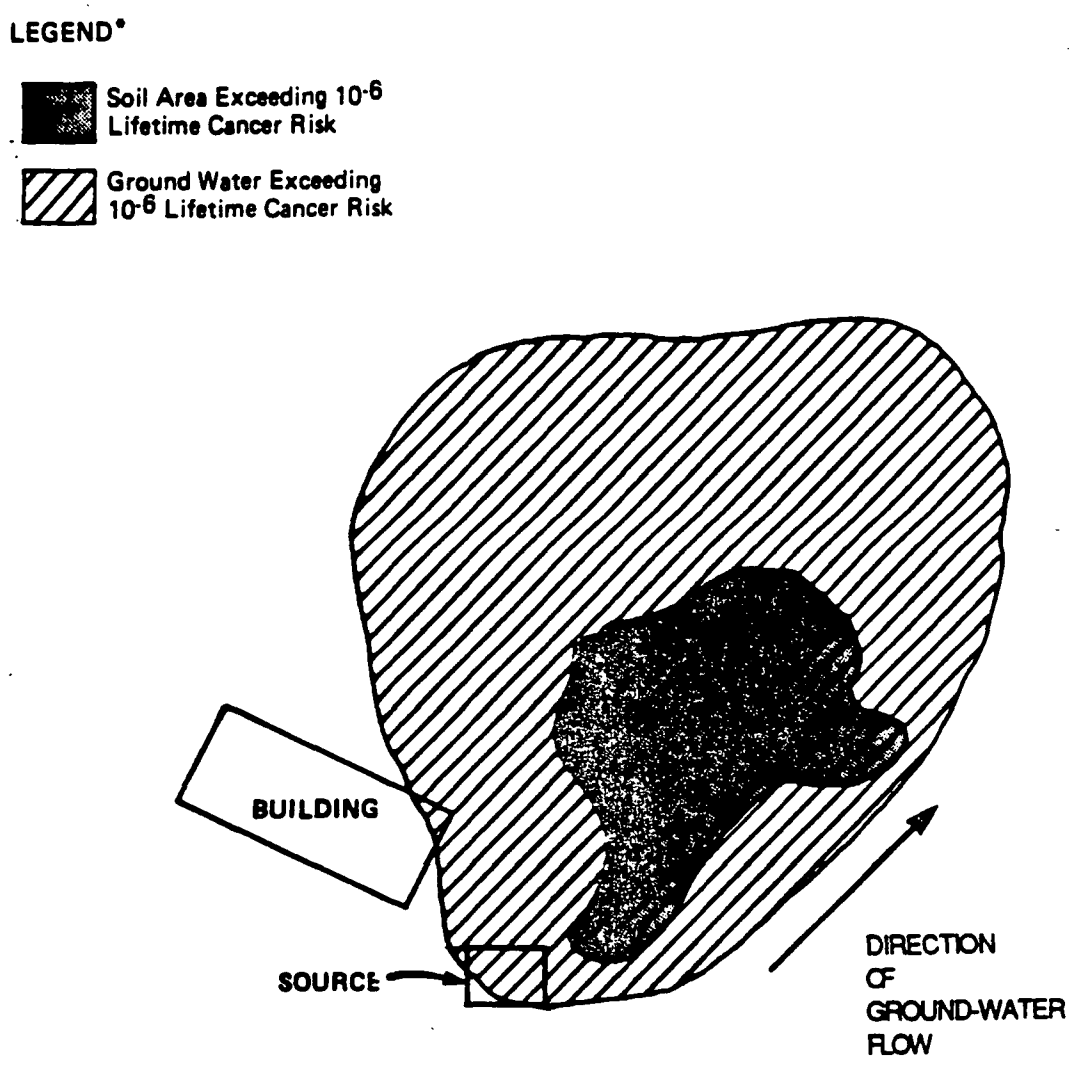
Data on source characteristics should be analyzed to describe the source location; the type and integrity of any existing waste containment; and the types, quantities, chemical and physical properties, and concentrations of hazardous substances found. The actual and potential magnitude of releases from the source and the mobility and persistence of source contaminants should be evaluated.

3.4.1.3 The Nature and Extent of Contamination

An analysis of data collected concerning the study area should be performed to describe contaminant concentration levels found in environmental media in the study area. Analyses that are important to the subsequent risk assessment and subsequent development of remedial alternatives include the horizontal and vertical extent of contamination in soil, ground water, surface water, sediment, air, biota, and facilities. Spatial and temporal trends in contamination may be important in evaluating transport pathways. Data should be arranged in tabular or graphical form for clearer understanding. Figure 3-2 shows an example of how the extent of soil and ground-water contamination can be represented in terms of excess lifetime cancer risk. Similar figures can be prepared showing concentrations rather than risk values.

FIGURE 3-2

REPRESENTATION OF THE EXTENT OF CONTAMINATION



*NOTE: 1. Site-specific features should be shown as appropriate (e.g., actual or potential ground-water users).

2. Contamination can be represented by concentrations rather than risk levels.

3.4.1.4 Contaminant Fate and Transport

Results of the site physical characteristics, source characteristics, and extent of contamination analyses are combined in the analyses of contaminant fate and transport. If information on the contaminant release is available, the observed extent of contamination may be used in assessing the transport pathway's rate of migration and the fate of contaminants over the period between release and monitoring. Contaminant fate and transport may also be estimated on the basis of site physical characteristics and source characteristics.

Either analysis may use analytical or numerical modeling. While field data generally best define the extent of contamination, models can interpolate among and extrapolate from isolated field samples and can interpret field data to create a more detailed description. Models also can aid the data reduction process by providing the user with a structure for organizing and analyzing field data.

Models applicable to site characterization can be grouped according to their relative accuracy and their ability to depict site conditions. Simplified models (e.g., analytical and semianalytical models) can quantitatively estimate site conditions with relatively low accuracy and resolution. Typically, they provide order-of-magnitude estimates (U.S. EPA, 1982a) and require that simplified assumptions be made regarding site conditions and chemical characteristics.

More detailed numerical models (e.g., numerical computer codes) provide greater accuracy and resolution (U.S. EPA, 1982a), because they are capable of representing spatial variations in site characteristics and irregular geometries commonly found at actual sites. These models can also represent the actual configuration and effects of remedial actions on site conditions. Detailed mathematical models are sometimes appropriate for investigations in which detailed information on contaminant fate and transport is required.

Models are also useful for screening alternative remedial actions and may be used for a detailed analysis of alternatives. Deciding whether analytical or numerical models should be used and selecting appropriate models for either the remedial investigation or the feasibility study can be difficult. Detailed modeling may not be needed if site conditions are well understood and if the potential effectiveness of different remedial actions can be easily evaluated. In selecting and applying models, it is important to remember that a model is an artificial representation of a physical system and is only one way of characterizing and assessing a site. A model cannot replace, nor can it be more accurate than, the actual site data.

3.4.2 Baseline Risk Assessment

3.4.2.1 General Information

Baseline risk assessments provide an evaluation of the potential threat to human health and the environment in the absence of any remedial action. They provide the basis for determining whether or not remedial action is necessary and the justification for performing remedial actions. Detailed guidance on conducting risk assessments is provided in the Superfund Public Health Evaluation Manual (SPHEM) (EPA/540/1-861060, OSWER Directive 9285.4-1, October 1986).

In general, the objectives of a baseline risk assessment may be attained by identifying and characterizing the following:

- Toxicity and quantity of hazardous substances present in relevant media (e.g., air, ground water, soil, surface water, sediment, and biota)

- Environmental fate and transport mechanisms within specific environmental media such as physical, chemical, and biological degradation processes and hydrogeological conditions

- Potential exposure pathways and extent of actual or expected exposure

- Potential human and environmental receptors

- Extent of expected impact or threat; and the likelihood of such impact or threat occurring (i.e., risk characterization)

- "Acceptable" levels of exposure based on regulatory and toxicological information

The level of effort required to conduct a baseline risk assessment depends largely on the complexity of the site. The goal is to gather sufficient information to adequately, and as accurately as possible, characterize the potential risk from a site, while at the same time conduct this assessment as efficiently as possible. Use of the conceptual exposure model developed and refined previously will help focus investigation efforts and, therefore, streamline this effort. Factors that may affect the level of effort required include:

- The number, concentration, and identity of chemicals present

- The quality and quantity of available monitoring data

- The number and complexity of exposure pathways (including the complexity of release sources and transport media)

- The necessity for precision of the results, which in turn depends on onsite conditions such as the extent of contaminant migration and the proximity, characteristics, and size of potentially exposed population(s)

- The availability of appropriate standards and/or toxicity data

- The likelihood that no action will be the chosen alternative. If no action is a likely choice, it is necessary that all potential pathways and routes of exposure have been thoroughly assessed to ensure that the site poses no threat to human health and the environment.

3.4.2.2 Components of the Baseline Risk Assessment

The risk assessment process can be divided into four components:

- Contaminant identification
- Exposure assessment
- Toxicity assessment
- Risk characterization

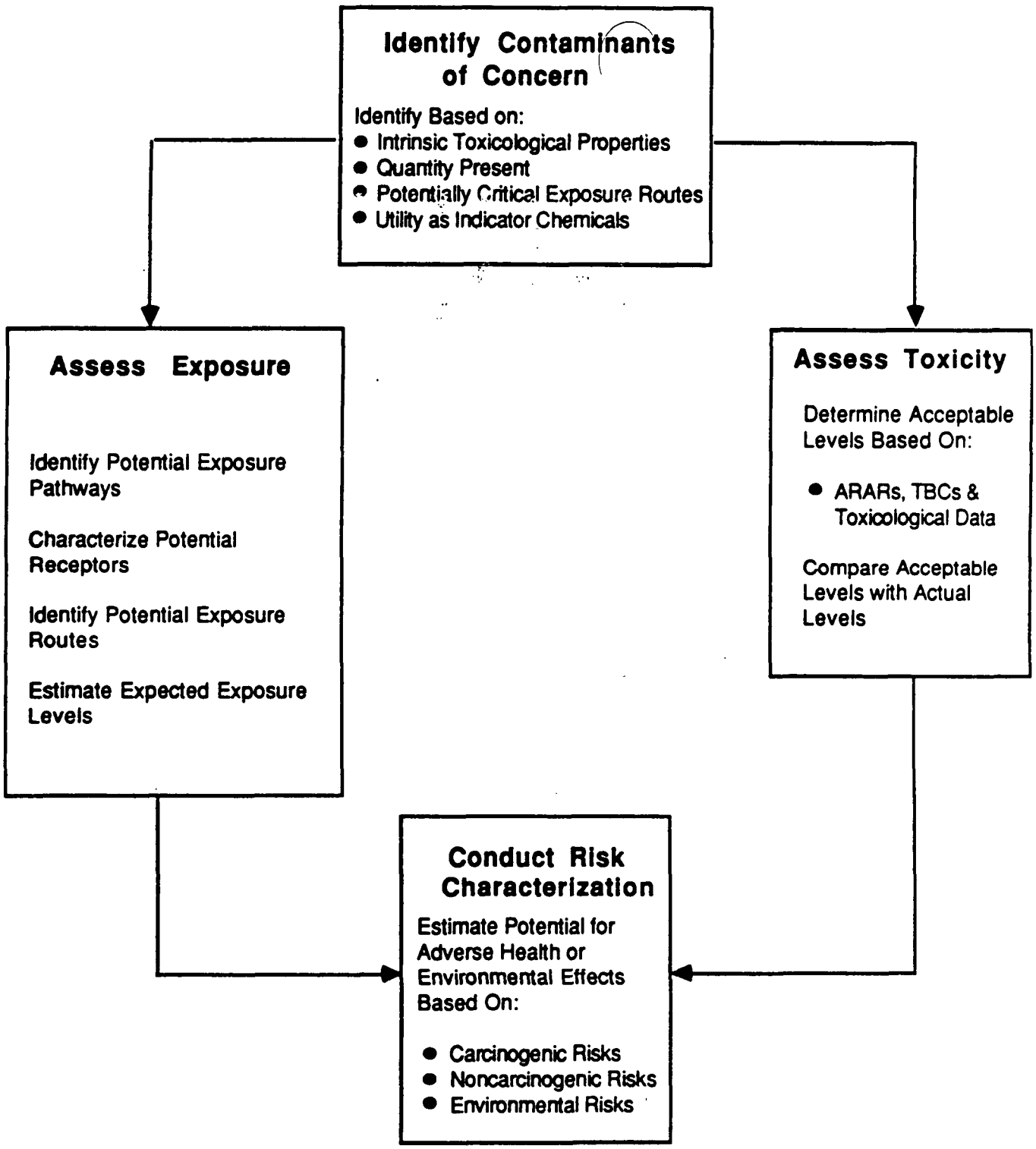
Figure 3-3 illustrates the risk assessment process and its four components. The following provides a brief overview of each component.

Contaminant Identification. The objective of contaminant identification is to screen the information that is available on hazardous substances or wastes present at the site and to identify contaminants of concern to focus subsequent efforts in the risk assessment process. Contaminants of concern may be selected because of their intrinsic toxicological properties, because they are present in large quantities, or because they are present in potentially critical exposure pathways (e.g., drinking water supply).

It may be useful for some sites to select "indicator chemicals" as part of this process. The methodology for identifying indicator chemicals is described in the SPHEM. Indicator chemicals are to represent the most toxic and/or mobile substances among those identified or those substances for which the best information is available.

Exposure Assessment. The objectives of an exposure assessment are to identify actual or potential exposure pathways, to characterize the

FIGURE 3-3
COMPONENTS OF THE RISK ASSESSMENT PROCESS



potentially exposed populations, and to determine the extent of the exposure. Detailed guidance on conducting exposure assessments is discussed in the Superfund Exposure Assessment Manual (EPA, under development). These objectives are attained by:

- o Identifying exposure pathways
- o Analyzing exposed populations
- o Estimating expected exposure levels

Identifying potential exposure pathways helps to conceptualize how contaminants may migrate from a source to an existing or potential point of contact. An exposure pathway consists of four elements:

1. A source and mechanism of chemical release to the environment

2. An environmental transport medium (e.g., air, ground water) for the released chemical

3. A point of potential contact with the contaminated medium (referred to as the exposure point)

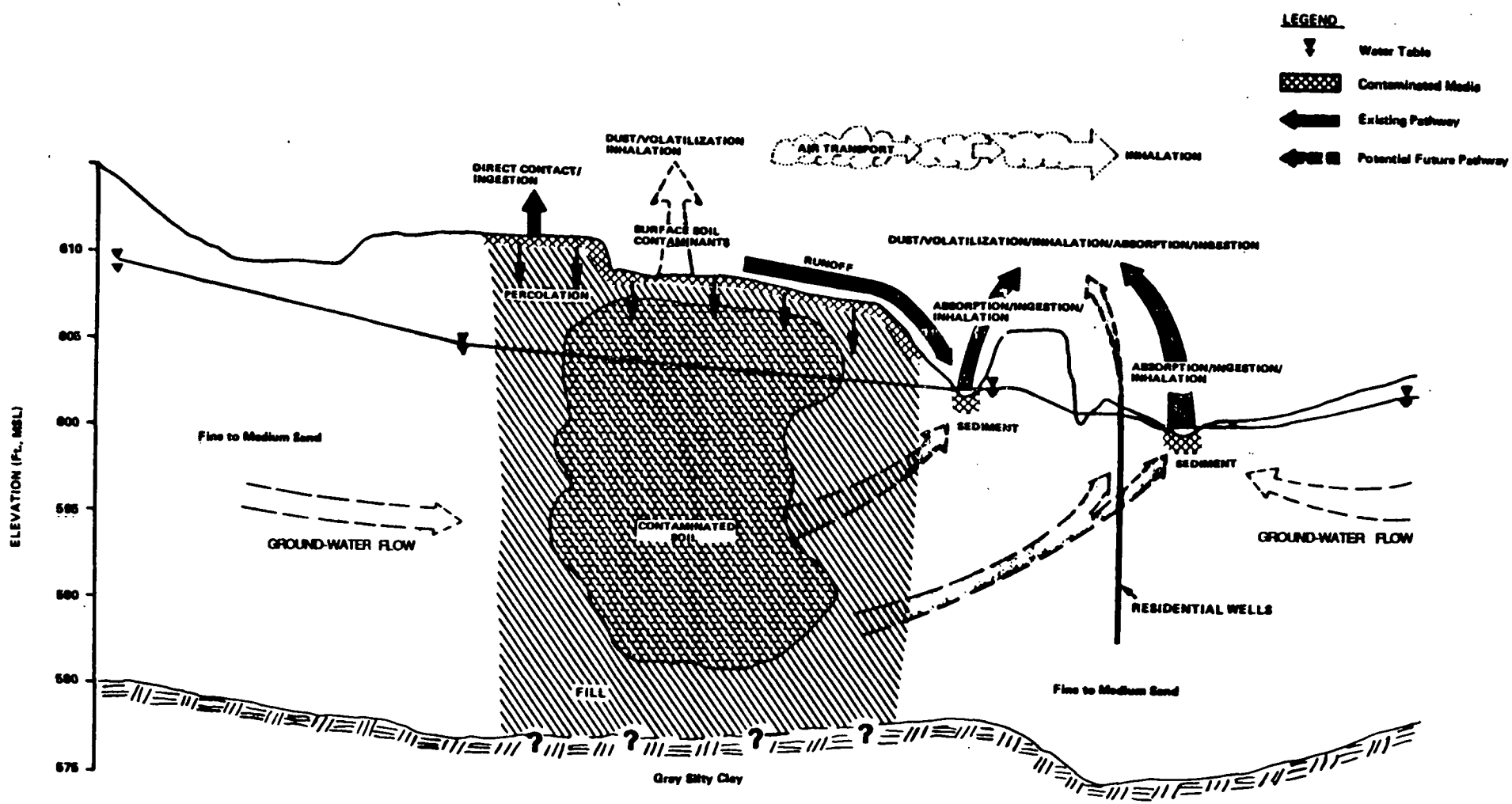
4. An exposure route (e.g., inhalation, ingestion) at the contact point

The first element of an exposure pathway analysis is an analysis of the contaminant source and how contaminants may be released. This analysis involves characterizing the contaminants of concern at the site and determining the amount of concentration and the mean and maximum concentrations of each contaminant released to each environmental medium. Figure 3-4 presents a conceptual example identifying actual and potential exposure pathways.

In the second element of exposure pathway analysis, the environmental fate and transport of the contaminants are analyzed. This portion considers environmental transport (e.g., ground-water migration, airborne transport); transformation (e.g., biodegradation, hydrolysis, and photolysis); and transfer mechanisms (e.g., sorption, volatilization). The results of these

FIGURE 3-4 IDENTIFICATION OF EXPOSURE PATHWAYS

OSWER Directive 9355.3-01



analyses provide information on the potential magnitude and extent of environmental contamination.

The third element identifies potential exposure points for receptors. To estimate the potential worst-case total risk, the locations of the highest potential exposure concentrations for a given release source and transport media combination should be estimated, along with the concentration of contaminants at that point. Exposure points with lower predicted chemical concentrations and large existing potentially exposed populations also need to be evaluated.

The fourth element of exposure pathway analysis is the identification and description of potential exposure routes. Exposure routes describe how a receptor can come into contact with contaminants in a specific environmental medium. Environmental media to be considered include air, ground water, surface water, soil and sediment, and food. Exposure routes include ingestion, dermal absorption, and inhalation. Procedures for estimating and calculating rates of exposure are described in detail in the Superfund Exposure Assessment Manual.

After the exposure pathway analysis is completed, the potential for exposure to populations should be assessed. This may involve gathering information on the frequency, mode, and magnitude of exposure. These data are then assessed to yield a value that represents the amount of contaminated media contacted per day. This analysis should include not only identification of currently exposed populations but also exposures that may occur in the future if no action is taken at the site. Because the frequency of human exposures will vary based on whether the primary use of the site is residential, industrial, or recreational, the expected land use should be evaluated. However, this evaluation does not require the prediction of future development, only that the likely use (and expected exposure scenarios on the basis of that land use) be evaluated. Part of this evaluation should include the development of a maximum plausible exposure scenario (i.e., worst-case scenario) for comparative purposes during the risk management decisionmaking process.

The final step in the exposure assessment is to integrate the information and develop a qualitative or quantitative estimate of the expected exposure level(s) resulting from the actual or potential release of contaminants from the site.

Toxicity Assessment. To assess the risks from a site, a comparison of acceptable levels of contamination with actual levels identified during the exposure assessment must be made. Contaminant-specific ARARs, when available, should be used to determine acceptable levels. When ARARs are not available or ARARs represent a risk greater than 10^{-4}, acceptable levels should be based on concentration levels that would yield exposures less than or equal to reference doses (RfDs) for noncarcinogens and specified risk levels based on potency factors (q_1*s) for carcinogens. The preliminary goals for carcinogens will be based on the risk range of 10^{-4} to 10^{-7} excess lifetime cancer risk.

While priority will be given to the RfDs and q_1*s in setting these goals, other available values may be useful in establishing final chemical-specific cleanup levels. Additional guidance on the use of RfDs and q_1*s for calculating acceptable concentrations in environmental media or for determining the toxicity of substances for which RfDs or q_1*s have not been developed is provided in the SPHEM.

Risk Characterization. In the final component of the risk assessment process, risk characterizations--the potential for adverse health or environmental effects for each of the exposure scenarios derived in the exposure assessment--are estimated. These estimates are attained by integrating information developed during the exposure and toxicity assessments to characterize the potential or actual risk including carcinogenic risks, noncarcinogenic risks, and environmental risks. The final assessment should include a summary of the risks associated with a site including each projected exposure route for contaminants of concern and the distribution of risk across various sectors of the population. In addition, such factors as the weight-of-evidence associated with toxicity information, the estimated

uncertainty of the component parts, and the assumptions contained within the estimates should be discussed.

Characterization of the environmental risks involves identifying the potential exposures to the surrounding ecological receptors and evaluating the potential effects associated with such exposure(s). Important factors to consider include disruptive effects to populations (both plant and animal) and the extent of perturbations to the ecological community.

The results of the baseline risk assessment may indicate that the site poses little or no threat to human health or the environment. In such situations, the FS should either be scaled down as appropriate to that site and its potential hazard or eliminated altogether. The results of the remedial investigation and the baseline risk assessment will therefore serve as the primary means of documenting a no-action decision. If it is decided that the scope of the FS will be less than what is presented in this guidance or eliminated all together, the lead agency should document this decision and receive the concurrence of the support agency.

3.4.3 Evaluate Data Needs

As data are collected and a better understanding of the site and the risks that it poses are obtained, the preliminary remedial action alternatives developed during scoping should be reviewed and refined. The available data should be evaluated to determine if they are sufficient to develop remedial alternatives. If they are not, additional data gathering will be required. When sufficient data are available, preliminary remedial response objectives with respect to the contaminants of concern, the areas and volumes of contaminated media, and existing and potential exposure routes and receptors of concern can begin to be developed as part of the FS.

3.5 DATA MANAGEMENT PROCEDURES

An RI may generate an extensive amount of information, the quality and validity of which must be consistently well documented because this

information will be used to support remedy selection decisions and any legal or cost recovery actions. Therefore, field sampling and analytical procedures for the acquisition and compilation of field and laboratory data are subject to data management procedures.[1] The discussion on data management procedures is divided into three categories: field activities, sample management and tracking, and document control and inventory.

3.5.1 Field Activities

During site characterization and sampling, consistent documentation and accurate recordkeeping procedures are critical because subsequent decisionmaking will be based on information gathered during these tasks. Aspects of data management for sampling activities during site characterization include:

- QA/QC Plans--These documents provide records of responsibility, adherence to prescribed protocols, nonconformity events, corrective measures, and data deficiencies.

- A Data Security System--This system outlines the measures that will be taken in the field to safeguard chain-of-custody records and prevent free access to project records, thereby guarding against accidental or intentional loss, damage, or alteration.

- Field Logs--The daily field logs are the primary record for field investigation activities and should include a description of any modifications to the procedures outlined in the work plan, field sampling plan, or health and safety plan, with justifications for such modifications. Field measurements and observations should be recorded directly into the project log books. Examples of field measurements include pH, temperature, conductivity, water flow, air quality parameters, and soil characteristics. Health and

[1] Data quality objectives will govern the data management methods used, and the QAPP/FSP will identify both field-collected and analytical data. This material should include sampling information, recording procedures, sample management, and QC concerns.

safety monitoring, sampling locations, sampling techniques, and a general description of daily activity are typically included in the daily log. Any unusual occurrences or circumstances should be documented in these logs and can be used for reference in determining the possible causes for data anomalies discovered during data analysis. Data must be recorded directly and legibly in field log books with entries signed and dated. Changes made to original notes should not obliterate the original information and should be dated and signed. Standard format information sheets should be used whenever appropriate and should be retained in permanent files.

Documentation involved in maintaining field sample inventories and proper chain-of-custody records may include the following[1]:

- Sample Identification Matrix
- Sample Tag
- Traffic Report
- High-Hazard Traffic Report
- SAS Packing List
- Chain-of-Custody Form
- Notice of Transmittal
- Receipt for Samples Form
- CRL Sample Data Report
- Shipping Airbill

Additional information for each of these items, along with the instructions for their completion, can be found in Section 6.2 of the Compendium of Superfund Field Operations Methods.

[1]Specific requirements may vary between State- and Federal-lead sites.

3.5.2 Sample Management and Tracking

A record of sample shipments, receipt of analytical results, submittal of preliminary results for QA/QC review, completion of QA/QC review, and evaluation of the QC package should be maintained to ensure that only final and approved analytical data are used in the site analysis. In some instances, the use of preliminary data is warranted to prepare internal review documents, to begin data analysis while minimizing lost time for the turnaround of QA/QC comments, and to continue narrowing remedial action alternatives. Preliminary data are considered unofficial; however, until the QA/QC package is complete, any preliminary data used in analysis must be updated upon receipt of official QA/QC comments and changes. Sample results should not be incorporated in the site characterization report unless accompanied by QA/QC comments.

The data quality objectives stated for each task involving sample analysis must specify whether the information is valid with qualifiers or not and must specify which qualifiers can invalidate the use of certain data. For instance, reproducibility of plus or minus 20 percent may be acceptable in a treatability study but may not be acceptable for determining the treatment for establishing a risk to human health from drinking water. Acceptability of data quality is not established until the reviewed QA/QC package accompanies the analytical data.

The acceptable QA/QC package should be defined in the approved site QAPP for each discrete task. Where use of the CLP is involved, review by the CRL QA Office is typical but may vary from one Region to the next and may vary from one state to the next in the case of State-lead sites. Nevertheless, the data quality objectives outlined for the use of the data will dictate the level of review required.

3.5.3 Document Control and Inventory

Sample results should be managed in a standardized form to promote easy reporting of data in the site characterization report. Precautions should

be taken in the analysis and storage of the data collected during site characterization to prevent the introduction of errors or the loss or misinterpretation of data.

The document inventory and filing systems can be based on serially numbered documents. These systems may be manual or automated. A suggested structure and sample contents of a file for Superfund activities are shown in Table 3-11. The relationship of this filing system to the Administrative Record is discussed in the "Administrative Record Guidance" (under development).

3.6 COMMUNITY RELATIONS ACTIVITIES DURING SITE CHARACTERIZATION

Two-way communication with interested members of the community should be maintained throughout the remedial investigation. The remedial project manager and Community Relations Coordinator keep local officials and concerned citizens apprised of site activities and of the schedule of events by implementing several community relation activities. These actions are usually delineated in the community relations plan and typically include, but are not limited to, public information meetings at the beginning and end of the remedial investigation; a series of fact sheets that will be distributed to the community during the investigation and will describe up-to-date progress and plans for remedial activities; telephone briefings of key members of the community--public officials and representatives of concerned citizens; and periodic news releases that describe progress at the site.

The files containing the administrative record should be established once the RI/FS work plan is finalized and kept at or near the site. It is recommended that the files containing the Administrative Record be kept at one of the information repositories for public information at or near the site and near available copying facilities. Copies of site-related information should be made available to the community and should typically include the RI/FS work plan, a summary of monitoring results, fact sheets, and the community relations plan. The objective of community relations

Table 3-11
OUTLINE OF SUGGESTED FILE STRUCTURE FOR SUPERFUND SITES

Congressional Inquiries and Hearings:

- Correspondence
- Transcripts
- Testimony
- Published hearing records

Remedial Response:

- Discovery
  - Initial investigation reports
  - Preliminary assessment report
  - Site inspection report
  - Hazard Ranking System data
- Remedial planning
  - Correspondence
  - Work plans for RI/FS
  - RI/FS reports
  - Health and safety plan
  - Quality assurance/quality control plan
  - Record of Decision/responsiveness summary
- Remedial implementation
  - Remedial design reports
  - Permits
  - Contractor work plans and progress reports
  - Corps of Engineers agreements, reports, and correspondence
- State and other agency coordination
  - Correspondence
  - Cooperative agreement/Superfund State contract
  - State quarterly reports
  - Status of State assurances
  - Interagency agreements
  - Memorandum of Understanding with the state

Table 3-11 (continued)

- Community relations
  - Interviews
  - Correspondence
  - Community relations plan
  - List of people to contact, e.g., local officials, civic leaders, environmental groups
  - Meeting summaries
  - Press releases
  - News clippings
  - Fact sheets
  - Comments and responses
  - Transcripts
  - Summary of proposed plan
  - Responsiveness summary

Imagery:

- Photographs
- Illustrations
- Other graphics

Enforcement:

- Status reports
- Cross-reference to any confidential enforcement files and the person to contact
- Correspondence
- Administrative orders

Contracts:

- Site-specific contracts
- Procurement packages
- Contract status notifications
- List of contractors

Financial Transactions:

- Cross-reference to other financial files and the person to contact
- Contractor cost reports
- Audit reports

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activities during the RI is to educate the public on the remedial process and keep the community informed of project developments as they occur, thereby reducing the likelihood of conflict arising from a lack of information, misinformation, or speculation. As directed in the community relations plan, all activities should be tailored to the community and to the site.

3.7 REPORTING AND COMMUNICATION DURING SITE CHARACTERIZATION

During site characterization, communication is required between the lead agency and the support agency. In addition to routine communication between members of the lead agency and their contractor on project progress, written communication is required between the lead agency and the support agency as follows:

1. The lead agency should provide the draft work plan to the support agency for review and comment.

2. The lead agency should provide information on contaminant types and affected media to the support agency for ARAR identification.

3. The lead agency should provide a preliminary summary of site characterization to the support agency (this may serve as the mechanism for ARAR identification).

4. The lead agency should provide a draft RI report for review and comment by the support agency.

These communication requirements are discussed in the following section. Table 3-12 summarizes the points during site characterization when written or verbal communication is recommended.

Table 3-12
REPORTING AND COMMUNICATION DURING SITE CHARACTERIZATION

Information Needed	Purpose	Potential Methods of Information Provision
Need to rescope field activities on the basis of results of field observations	Needed only if screening indicates that field activities need to be rescoped; for lead agency and contractor to identify methods to improve effectiveness of site characterization activities; for lead agency to obtain support agency review and concurrence	Meeting Tech memo Other
Need to rescope field activities on the basis of results of sample analysis	Needed only if analysis of lab data indicates field activities need to be rescoped; for lead agency and contractor to identify methods to improve effectiveness of site characterization activities; for lead agency to obtain support agency review and concurrence	Meeting Tech memo Other
Preliminary results of field investigation tasks (e.g., geophysical explorations, monitoring well installation, etc.)	Provided by the contractor to the lead agency; need and method of communication at lead agency's discretion	Tech memos Other
Descriptive and analytical results of initial site characterization results (excluding risk assessment)	May also be submitted to ATSDR for use in preparing health assessment; assists in supporting agency with identification of ARARs; provides lead agency with early summary of site data	Preliminary site characterization summary

Table 3-12 (continued)

Information Needed	Purpose	Potential Methods of Information Provision
Listing of contaminants, affected media; location of wetlands, historic sites, etc.	For support agency's use in identifying contaminant- and location-specific ARARS.	Preliminary site characterization summary
Refined remedial action objectives	For lead agency and contractor to define the basis for developing remedial action alternatives; obtain review and comment from the support agency	Meeting Tech memo Other
Documentation of site characterization field activities and analyses including any treatability testing	Required for members of lead agency and their contractor to prepare for public comment and FS support documentation	Draft RI report

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3.7.1 Information for ARAR Identification

The information for the support agency's use in identifying ARARs should include a description of the contaminants of concern, the affected media, and any physical features that may help identify location-specific ARARs. This information may be supplied by the preliminary site characterization summary (as discussed below) or by a letter or other document. The support agency shall provide location and contaminant-specific ARARs to the lead agency before preparation of the draft RI report.

3.7.2 Preliminary Site Characterization Summary

A summary of site data following the completion of initial field sampling and analysis should be prepared. This summary should briefly review investigative activities that have taken place and should strive to provide the lead agency with a reference for evaluating the development and screening of remedial alternatives. In addition, the preliminary site characterization summary may be used to assist the support agency in identification of ARARs and provide ATSDR with the data (prior to issuance of the draft RI) to assist their health assessment efforts.

The format of this summary is optional and left to the discretion of the lead-agency RPM. The format may range from a technical memorandum, which simply lists the locations and quantities of contaminants at the site, to a rough draft of the first four chapters of the RI report (see Table 3-13).

3.7.3 Draft RI Report

A draft RI report should be produced for review by the support agency and submitted to ATSDR for its use in preparing a health assessment. It also serves as documentation of data collection and analysis in support of the FS. The draft RI report can be prepared any time between the completion of the baseline risk assessment and the completion of the draft FS.

Therefore, the draft RI report should not delay the initiation or execution of the FS.

Table 3-13 gives a suggested format for the draft RI report. The report should focus on the media of concern and, therefore, does not need to address all the site characteristics listed in Table 3-13; only those appropriate at that specific site.

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Table 3-13
SUGGESTED RI REPORT FORMAT

Executive Summary

1. Introduction
   - 1.1 Purpose of Report
   - 1.2 Site Background
     - 1.2.1 Site Description
     - 1.2.2 Site History
     - 1.2.3 Previous Investigations
   - 1.3 Report Organization

2. Study Area Investigation
   - 2.1 Includes field activities associated with site characterization. These may include physical and chemical monitoring of some, but not necessarily all, of the following:
     - 2.1.1 Surface Features (topographic mapping, etc.) (natural and manmade features)
     - 2.1.2 Contaminant Source Investigations
     - 2.1.3 Meteorological Investigations
     - 2.1.4 Surface-Water and Sediment Investigations
     - 2.1.5 Geological Investigations
     - 2.1.6 Soil and Vadose Zone Investigations
     - 2.1.7 Ground-Water Investigations
     - 2.1.8 Human Population Surveys
     - 2.1.9 Ecological Investigations
   - 2.2 If technical memoranda documenting field activities were prepared, they may be included in an appendix and summarized in this report chapter.

3. Physical Characteristics of the Study Area
   - 3.1 Includes results of field activities to determine physical characteristics. These may include some, but not necessarily all, of the following:
     - 3.1.1 Surface Features
     - 3.1.2 Meteorology
     - 3.1.3 Surface-Water Hydrology
     - 3.1.4 Geology
     - 3.1.5 Soils
     - 3.1.6 Hydrogeology
     - 3.1.7 Demography and Land Use
     - 3.1.8 Ecology

Table 3-13 (continued)

4. Nature and Extent of Contamination
   - 4.1 Presents the results of site characterization, both natural chemical components and contaminants in some, but not necessarily all, of the following media:
     - 4.1.1 Sources (lagoons, sludges, tanks, etc.)
     - 4.1.2 Soils and Vadose Zone
     - 4.1.3 Ground Water
     - 4.1.4 Surface Water and Sediments
     - 4.1.5 Air

5. Contaminant Fate and Transport
   - 5.1 Potential Routes of Migration (i.e., air, ground water, etc.)
   - 5.2 Contaminant Persistence
     - 5.2.1 If they are applicable (i.e., for organic contaminants), describe estimated persistence in the study area environment and physical, chemical, and/or biological factors of importance for the media of interest.
   - 5.3 Contaminant Migration
     - 5.3.1 Discuss factors affecting contaminant migration for the media of importance (e.g., sorption onto soils, solubility in water, movement of ground water, etc.)
     - 5.3.2 Discuss modeling methods and results, if applicable.

6. Baseline Risk Assessment
   - 6.1 Public Health Evaluation
     - 6.1.1 Exposure Assessment
     - 6.1.2 Toxicity Assessment
     - 6.1.3 Risk Characterization
   - 6.2 Environmental Assessment

7. Summary and Conclusions
   - 7.1 Summary
     - 7.1.1 Nature and Extent of Contamination
     - 7.1.2 Fate and Transport
     - 7.1.3 Risk Assessment
   - 7.2 Conclusions
     - 7.2.1 Data Limitations and Recommendations for Future Work
     - 7.2.2 Recommended Remedial Action Objectives

Appendixes

A. Technical Memoranda on Field Activities (if available)
B. Analytical Data and QA/QC Evaluation Results
C. Risk Assessment Methods

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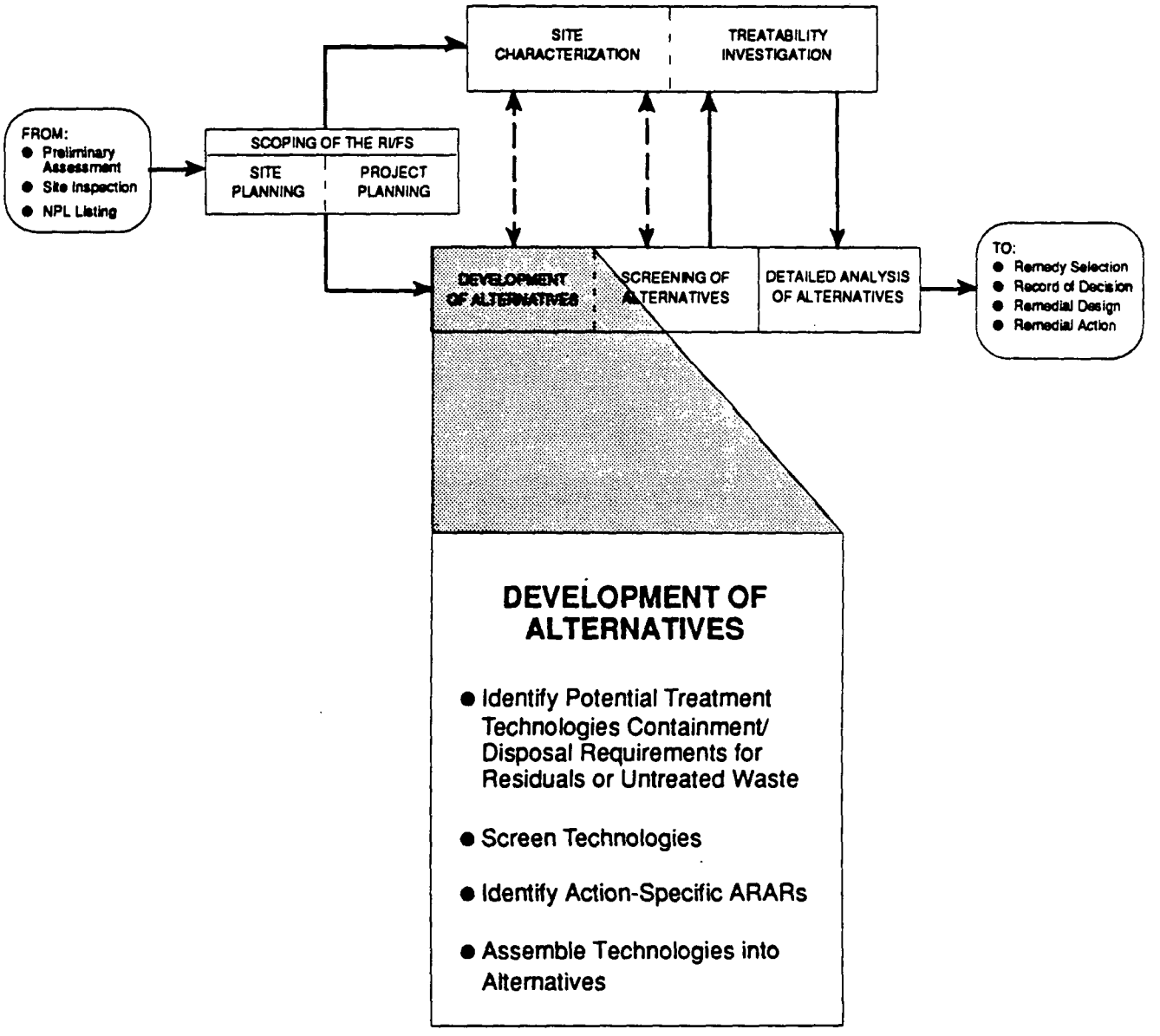
CHAPTER 4
DEVELOPMENT OF ALTERNATIVES



CHAPTER 4
DEVELOPMENT OF ALTERNATIVES

4.1 INTRODUCTION

4.1.1 Purpose of Alternative Development

The primary objective of this phase of the FS is to develop alternatives that protect human health and the environment and encompass a range of appropriate waste management options. Appropriate waste management options may involve, depending on site-specific circumstances, eliminating the hazardous substances at the site, reducing hazardous substances to acceptable levels, and preventing exposure to hazardous substances or some combination of elimination, reduction, and exposure prevention. Alternatives are typically developed concurrently with the RI site characterization, with the results of one influencing the other in an iterative fashion (i.e., RI site characterization data are used to develop alternatives and screen technologies, whereas the range of alternatives developed guides subsequent site characterization and/or treatability studies, as appropriate).

In developing alternatives, two important activities take place. First, volumes or areas of media are identified to which treatment and containment actions may be applied, possibly in combination with excavation, disposal, or institutional actions. The media to be treated or contained are determined by information on the nature and extent of contamination, ARARs, and risk factors. Second, the remedial action alternatives and associated technologies identified during project planning (Section 2.3) and any newly identified technologies are screened to identify those that would be effective for the contaminants and media of interest at the site. The information obtained during these two activities is used in assembling technologies (and the media to which they

will be applied) into alternatives for the site as a whole or a specific operable unit. An overview of the entire FS process is presented in the following subsections.

4.1.2 FS Process Overview

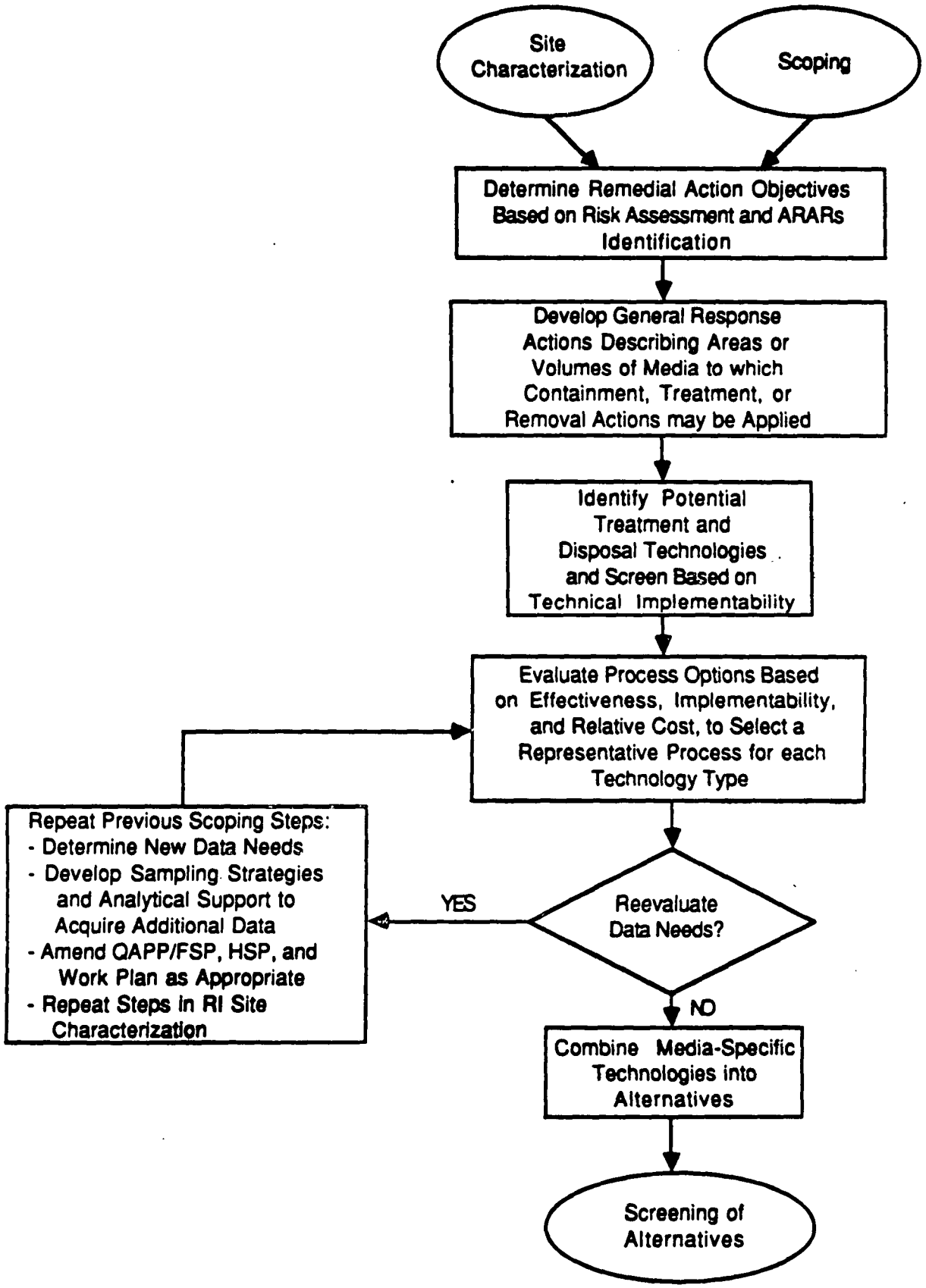
The feasibility study may be viewed (for explanatory purposes) as occurring in three phases: the development of alternatives, the screening of the alternatives, and the detailed analysis of alternatives. However, it is useful to note that there is no specific point at which one phase ends and the next begins. For example, the initial configurations of alternatives developed may be subsequently modified, refined, or eliminated during later FS phases as additional information becomes available on site conditions, technology performance, or the construction and operation requirements of alternatives. Furthermore, in those instances in which circumstances limit the number of available options, and therefore the number of alternatives that are developed, it may not be necessary to screen alternatives prior to the detailed analysis.

4.1.2.1 Development of Alternatives

Alternatives for remediation are developed by assembling combinations of technologies, and the media to which they would be applied, into alternatives that address contamination on a sitewide basis or for an identified operable unit. This process consists of six general steps, which are shown in Figure 4-1 and briefly discussed below:

- Develop remedial action objectives specifying the contaminants and media of interest, exposure pathways, and remediation goals that permit a range of treatment and containment alternatives to be developed. The objectives developed are based on contaminant-specific ARARs, when available, and risk-related factors.

FIGURE 4 -1
ALTERNATIVE DEVELOPMENT



- Develop general response actions for each medium of interest defining containment, treatment, excavation, pumping, or other actions, singly or in combination, that may be taken to satisfy the remedial action objectives for the site.

- Identify volumes or areas of media to which general response actions might be applied, taking into account the requirements for protectiveness as identified in the remedial action objectives and the chemical and physical characterization of the site.

- Identify and screen the technologies applicable to each general response action to eliminate those that cannot be implemented technically at the site.[1] The general response actions are further defined to specify remedial technology types (e.g., the general response action of treatment can be further defined to include chemical or biological technology types).

- Identify and evaluate technology process options to select a representative process for each technology type retained for consideration. Although specific processes are selected for alternative development and evaluation, these processes are intended to represent the broader range of process options within a general technology type.

- Assemble the selected representative technologies into alternatives representing a range of treatment and containment combinations, as appropriate.

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[1] It is important to distinguish between this medium-specific technology screening step during development of alternatives and the alternative screening that may be conducted subsequently to reduce the number of alternatives prior to the detailed analysis.

Figure 4-2 provides a generic representation of this process. Section 4.2 contains a more detailed description and specific examples of the alternative development phase.

4.1.2.2 Screening of Alternatives

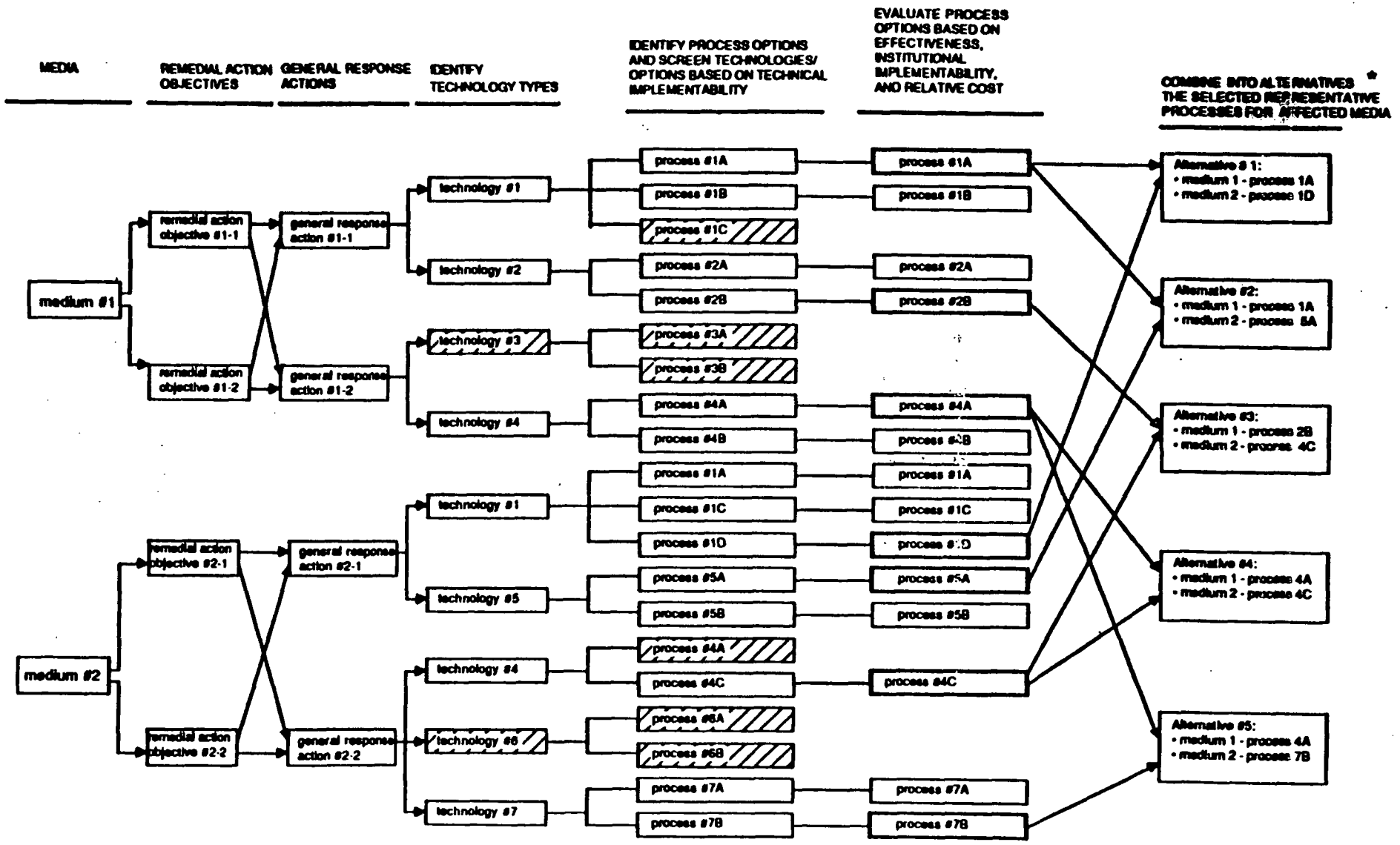
For those situations in which numerous waste management options were appropriate and developed, the assembled alternatives should be refined and screened to reduce the number of alternatives that will be analyzed in detail. In addition, the alternatives are analyzed to investigate interactions among media in terms of both the evaluation of technologies (i.e., the extent to which source control influences the degree of ground-water or air-quality control) and sitewide protectiveness (i.e., whether the alternative provides sufficient reduction of cumulative risk from all media and pathways for the site or that part of the site being addressed by an operable unit). On the basis of this analysis, alternatives may be modified or refined with respect to the technologies used or the volumes or areas of media to be affected.

The refined alternatives are evaluated on a general basis with respect to their effectiveness, implementability, and cost to identify the most promising alternatives which encompass an appropriate range of waste management options. As with the use of representative technologies, alternatives may be selected to represent sufficiently similar alternatives; thus, in effect, a separate analysis for each alternative is not warranted. Elements of the screening process are described at greater length in Chapter 5.

4.1.2.3 Detailed Analysis of Alternatives

During detailed analysis, the alternatives brought through screening are further refined, as appropriate, and analyzed in detail with respect to the nine evaluation criteria described in Chapter 7. Alternatives may be further refined and/or modified through additional site characterization or treatability studies conducted as part of the

FIGURE 4-2
GENERIC ALTERNATIVE DEVELOPMENT PROCESS



Legend: ▨ - Process options that are screened out ☐ - Process options selected to represent technology type

* Note: The combination of medium-technology options into sitewide alternatives may be conducted later in the FS if media interactions are insignificant.

RI. The detailed analysis should be conducted so that decisionmakers are provided with sufficient information to compare alternatives with respect to the nine evaluation criteria and to select an appropriate remedy. Analysis activities are described in greater detail in Chapter 7.

4.1.3 Alternative Ranges

Alternatives should be developed that will provide decisionmakers with an appropriate range of options and sufficient information to adequately compare alternatives against one another. In developing alternatives, the range of options will vary depending on site-specific conditions. A description of ranges for source control and ground-water response actions that should be developed, as appropriate, are described below.

4.1.3.1 Source Control Actions

For source control actions, the following types of alternatives should be developed to the extent practicable:

- A number of treatment alternatives ranging from one that would eliminate, or minimize to the extent feasible, the need for long-term management (including monitoring) at a site to one that would use treatment as a primary component of an alternative to address the principal threats at the site[1]

- One or more alternatives that involve containment of waste with little or no treatment but protect human health and the environment by preventing potential exposure and/or by reducing the mobility

- A no-action alternative

[1]Alternatives for which treatment is a principal element could include containment elements as well.

Figure 4-3 conceptually illustrates this range for source control alternatives.

Development of a complete range of treatment alternatives will not be practical in some situations. Alternatives within this range typically will differ in the type and extent of treatment used and the management requirements of treatment residuals or untreated wastes. For example, for sites with large volumes of potentially low concentrated wastes such as some municipal landfills and mining sites, an alternative that eliminates the need for long-term management may not be reasonable given site conditions, the limitations of technologies, and extreme costs that may be involved. If a full range of alternatives is not developed, the reasons for doing so should be documented.

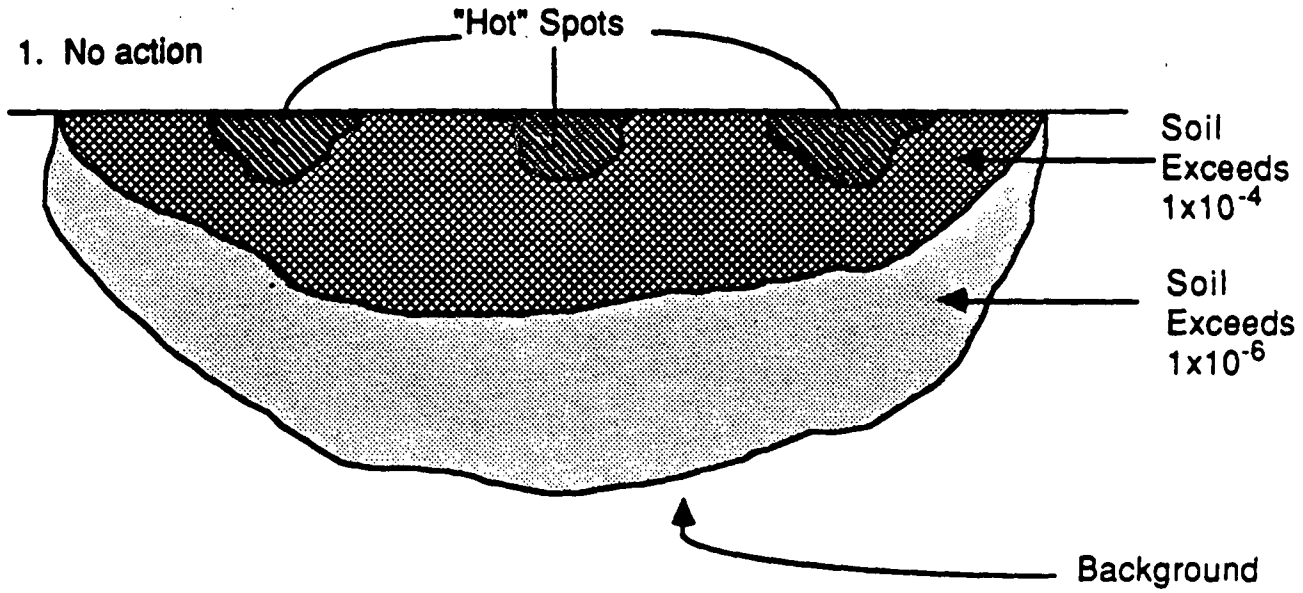
No-action alternatives may include some minimal actions such as fencing, using institutional controls, or monitoring, if no action at all is clearly not viable. If a no-action alternative with minimal controls is developed, a baseline risk assessment using no-action exposure scenarios will still need to be performed to help define cleanup goals for different media and the site as a whole.

4.1.3.2 Ground-water Response Actions

For ground-water response actions, alternatives should address not only cleanup levels but also the time frame within which the alternatives might be achieved. Depending on specific site conditions and the aquifer characteristics, alternatives should be developed that achieve ARARs or other risk-based levels determined to be protective within varying time frames using different methodologies. For aquifers currently being used as a drinking water source, alternatives should be configured that would achieve ARARs or risk-based levels as rapidly as possible. More detailed information on developing remedial alternatives for ground-water response actions may be found in "Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites (DRAFT)" (U.S. EPA, October 1986).

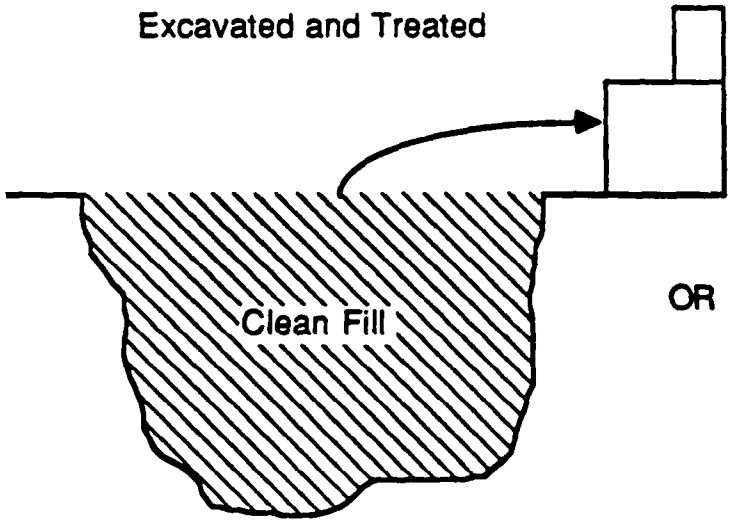
FIGURE 4-3

CONCEPTUAL TREATMENT RANGE FOR SOURCE CONTROL



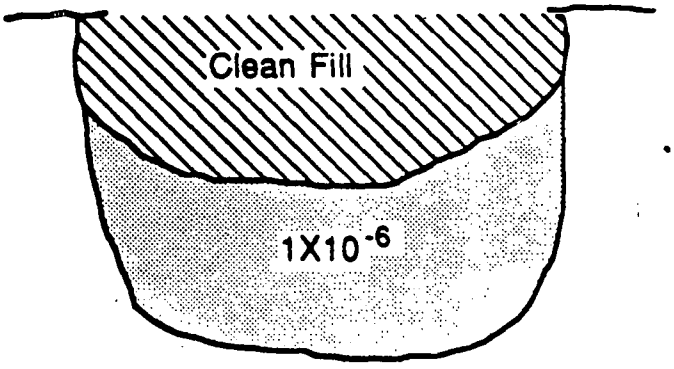
2. Treatment which eliminates or minimizes to the extent feasible the need for long-term management.

2A. All Contaminated Soil Excavated and Treated



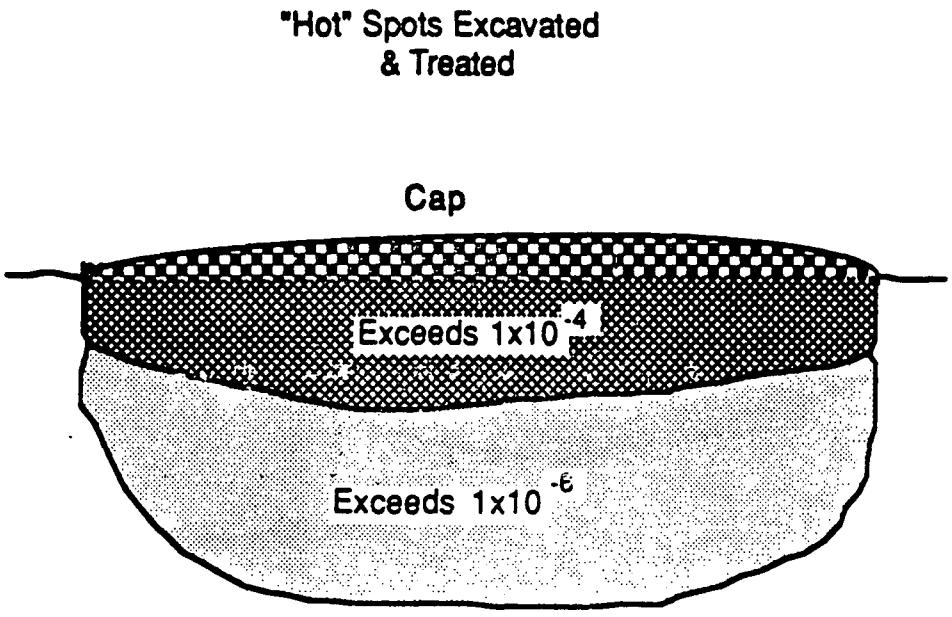
OR

2B. All Soil Above $1x10^{-6}$ Excavated & Treated

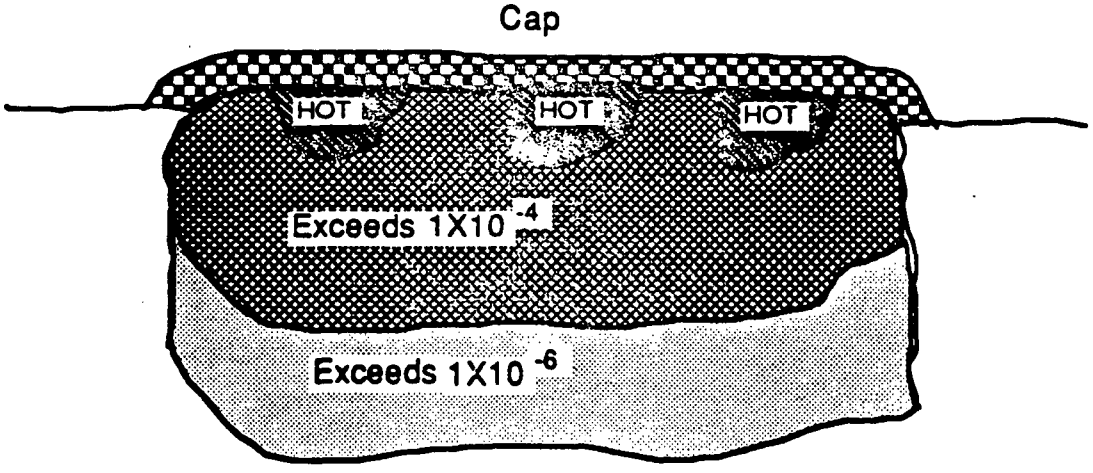


(Continued)

3. **Alternatives** using treatment as a principal element



4. Containment with little or no treatment



4.2 ALTERNATIVE DEVELOPMENT PROCESS

The alternative development process may be viewed as consisting of steps that involves making successively more specific definitions of potential remedial activities. These steps are described in the following sections.

4.2.1 Develop Remedial Action Objectives

Remedial action objectives consist of medium-specific or operable unit-specific goals for protecting human health and the environment. The objectives should be as specific as possible but not so specific that the range of alternatives that can be developed is unduly limited. Column two of Table 4-1 provides examples of remedial action objectives for various media.

Remedial action objectives aimed at protecting human health and the environment should specify:

- The contaminant(s) of concern
- Exposure route(s) and receptor(s)
- An acceptable contaminant level or range of levels for each exposure route

Remedial action objectives for protecting human receptors should express both a contaminant level and an exposure route, rather than contaminant levels alone, because protectiveness may be achieved by reducing exposure (such as capping an area, limiting access, or providing an alternate water supply) as well as by reducing contaminant levels. Because remedial action objectives for protecting environmental receptors typically seek to preserve or restore a resource (e.g., as ground water), environmental objective(s) should be expressed in terms of the medium of interest and target cleanup levels, whenever possible.

TABLE 4-1. TYPICAL REMEDIAL ACTION OBJECTIVES, GENERAL RESPONSE ACTIONS, TECHNOLOGY TYPES, AND EXAMPLE PROCESS OPTIONS FOR THE DEVELOPMENT AND SCREENING OF TECHNOLOGIES

Environmental Media	Remedial Action Objectives (from site characterization)	General Response Actions (for all remedial action objectives)	Remedial Technology Types (for general response actions)	Process Options
Ground Water	<u>For Human Health</u>: Prevent ingestion of water having [carcinogen(s)] in excess of [MCL(s)] and a total excess cancer risk (for all contaminants) of greater than 10^{-4} to 10^{-6}. Prevent ingestion of water having [non-carcinogen(s)] in excess of [MCL(s)] or [reference dose(s)]. <u>For Environmental Protection</u>: Restore ground water aquifer to [concentration(s)] for [contaminant(s)].	No Action/Institutional Actions: No action Alternative residential water supply Monitoring Containment Actions: Containment Collection/Treatment Actions: Collection/treatment discharge/ in situ groundwater treatment Individual home treatment units	No Action/Institutional Options: Fencing Deed restrictions Containment Technologies: Capping Vertical barriers Horizontal barriers Extraction Technologies: Ground water collection/pumping Enhanced removal Treatment Technologies: Physical treatment Chemical treatment In situ treatment Disposal Technologies: Discharge to POTW (after treatment) Discharge to surface water (after treatment)	 Clay cap, synthetic membrane, multi-layer Slurry wall, sheet piling Liners, grout injection Wells, subsurface or leachate collection Solution mining, vapor extraction, enhanced oil recovery Coagulation/flocculation, oil-water separation, air stripping, adsorption Neutralization, precipitation, ion exchange oxidation/reduction Subsurface bioreclamation
Soil	<u>For Human Health</u>: Prevent ingestion/direct contact with soil having [non-carcinogen(s)] in excess of [reference dose(s)]. Prevent direct contact/ ingestion with soil having 10^{-4} to 10^{-6} excess cancer risk from [carcinogen(s)]. Prevent inhalation of [carcinogen(s)] posing excess cancer risk levels of 10^{-4} to 10^{-7}. <u>For Environmental Protection</u>: Prevent migration of contaminants that would result in ground water contamination in excess of [concentration(s)] for [contaminant(s)].	No Action/Institutional Actions: No action Access restrictions Containment Actions: Containment Excavation/Treatment Actions: Excavation/treatment/disposal In situ treatment Disposal excavation	No Action/Institutional Options: Fencing Deed restrictions Containment Technologies: Capping Vertical barriers Horizontal barriers Surface controls Sediment control barriers Dust controls Removal Technologies: Excavation Treatment Technologies: Solidification, fixation, stabilization, immobilization Dewatering Physical treatment Chemical treatment Biological treatment In situ treatment Thermal treatment	 Clay cap, synthetic membrane, multi-layer Slurry wall, sheet piling Liners, grout injection Diversion/collection, grading, soil stabilization Coffer dams, curtain barriers Revegetation, capping Solids excavation Sorption, pozzolanic agents, encapsulation Belt filter press, dewatering, and drying beds Water/solvent leaching (with subsequent liquids treatment) Lime neutralization Cultured micro-organisms Surface bioreclamation Incineration, pyrolysis

TABLE 4-1
(continued)

Environmental Media	Remedial Action Objectives (from site characterization)	General Response Actions (for all remedial action objectives)	Remedial Technology Types (for general response actions)	Process Options
Surface Water	For Human Health: Prevent ingestion of water having [carcinogen(s)] in excess of [MCLs] and a total excess cancer risk of greater than 10^{-4} to 10^{-6}. Prevent ingestion of water having [non-carcinogen(s)] in excess of [MCLs] or [reference dose(s)]. For Environmental Protection: Restore surface water to [ambient water quality criteria] for [contaminant(s)].	No Action/Institutional Actions: No action Access restrictions Monitoring Collection/Treatment Actions: Surface water runoff interception/ treatment/discharge	No Action/Institutional Options: Fencing Deed restrictions Collection Technologies: Surface controls Treatment Technologies: Physical treatment Chemical treatment Biological treatment (organics) In situ treatment Disposal Technologies: Discharge to POTW (after treatment)	 Grading, diversion, and collection Coagulation/flocculation, oil-water separation, filtration, adsorption Precipitation, ion exchange, neutralization, freeze crystallization biological treatment, Aerobic and anaerobic spray irrigation In situ precipitation, in situ bioreclamation
Sediment	For Human Health: Prevent direct contact with sediment having [carcinogen(s)] in excess of 10^{-4} to 10^{-6} excess cancer risk. For Environmental Protection: Prevent release of [contaminant(s)] from sediments that would result in surface water levels in excess of [ambient water quality criteria].	No Action/Institutional Actions: No action Access restrictions to Monitoring Excavation Actions: Excavation Excavation/Treatment Actions: Removal/disposal Removal/treatment/disposal	No Action/Institutional Options: Fencing Deed restrictions Removal Technologies: Excavation Containment Technologies: Capping Vertical barriers Horizontal barriers Sediment control barriers Treatment Technologies: Solidification, fixation, stabilization Dewatering Physical treatment Chemical treatment Biological treatment In situ treatment Thermal treatment	 Sediments excavation Removal with clay cap, multi-layer, asphalt Slurry wall, sheet piling Liners, grout injection Coffer dams, curtain barriers, capping barriers Sorption, pozzolanic agents, encapsulation Sedimentation, dewatering and drying beds Water/solids leaching (with subsequent treatment) Neutralization, oxidation, electrochemical reduction Landfarming Surface bioreclamation Incineration, pyrolysis
Air	For Human Health: Prevent inhalation of [carcinogen(s)] in excess of 10^{-4} to 10^{-6} excess cancer risk.	No Action/Institutional Actions: No action Access restrictions to Monitoring Collection Actions: Gas collection	No Action/Institutional Options: Fencing Deed restrictions Removal Technologies: Landfill gas collection	 Passive vents, active gas collection systems

TABLE 4-1
(continued)

Environmental Media	Remedial Action Objectives (from site characterization)	General Response Actions (for all remedial action objectives)	Remedial Technology Types (for general response actions)	Process Options
Structures	For Human Health: Prevent direct contact with [carcinogen(s)] in excess of 10^{-4} to 10^{-6} excess cancer risk. Prevent migration of [carcinogen(s)] which would result in ground water concentrations in excess of [MCLs] or 10^{-4} to 10^{-7} total excess cancer risk level. Prevent migration of [carcinogen(s)] which would result in soil concentrations in excess of [reference dose(s)]. For Environmental Protection: Prevent migration of [contaminants] that would result in ground water concentrations in excess of [concentration(s)].	No Action/Institutional Actions: No action Access restrictions Demolition/Treatment Actions: Demolition/disposal Decontamination	No Action/Institutional Options: Fencing Deed restrictions Removal Technologies: Demolition Excavation Treatment Technologies: Solids processing Solids treatment	 Demolition Excavation, debris removal Magnetic processes, crushing and grinding, screening Water leaching, solvent leaching, steam cleaning
Solid Wastes	For Human Health: Prevent ingestion/direct contact with wastes having [non-carcinogen(s)] in excess of [reference dose(s)]. Prevent ingestion/direct contact with wastes having 10^{-4} to 10^{-6} excess cancer risk from [carcinogen(s)]. Prevent inhalation of [carcinogen(s)] posing excess cancer risk levels of 10^{-4} to 10^{-6}. Prevent migration of [carcinogen(s)] which would result in ground water concentrations in excess of [MCLs] or 10^{-4} to 10^{-7} total excess cancer risk levels.	No Action/Institutional Actions: No action Access restrictions to [location] Containment Actions: Containment Excavation/Treatment Actions: Removal/disposal Removal/treatment/disposal	No Action/Institutional Options: Fencing Deed restrictions Containment Technologies: Capping Vertical barriers Horizontal barriers Removal Technologies: Excavation Drum removal Treatment Technologies: Physical treatment Chemical treatment Biological treatment Thermal treatment Solids processing	 Clay cap, synthetic membranes, multi-layer Slurry wall, sheet piling Liners, grout injection Dust controls Solids excavation Drum and debris removal Water/solvent leaching (with subsequent liquids treatment) Neutralization Cultured micro-organisms Incineration, pyrolysis, gaseous incineration Crushing and grinding, screening, classification

TABLE 4-1
(continued)

Environmental Media	Remedial Action Objectives (from site characterization)	General Response Actions (for all remedial action objectives)	Remedial Technology Types (for general response actions)	Process Options
Solid Wastes (continued)	For Environmental Protection: Prevent migration of contaminants that would result in ground water contamination in excess of [concentration(s)] for [contaminant(s)].			
Liquid Wastes	For Human Health: Prevent ingestion/direct contact with wastes having [non-carcinogen(s)] in excess of [reference dose(s)]. Prevent ingestion/direct contact with wastes having 10^{-4} to 10^{-6} excess cancer risk from [carcinogen(s)]. Prevent inhalation of [carcinogen(s)] posing excess cancer risk levels of 10^{-4} to 10^{-7}. Prevent migration of [carcinogen(s)] which would result in groundwater concentrations in excess of [MCLs] or 10^{-4} to 10^{-7} total excess cancer risk levels. For Environmental Protection: Prevent migration of contaminants that would result in groundwater contamination in excess of [concentration(s)] for [contaminant(s)].	No Action/Institutional Actions: No action Access restrictions to [location] Containment Actions: Containment Removal/Treatment Actions: Removal/disposal Removal/treatment/disposal	No Action/Institutional Options: Fencing Deed restrictions Containment Technologies: Vertical barriers Horizontal barriers Removal Technologies: Bulk liquid removal Drum removal Treatment Technologies: Physical treatment Chemical treatment Biological treatment Thermal treatment (organics) Disposal Technologies: Produce reuse Discharge to POTW (after treatment)	 Slurry wall Liners Bulk liquid removal Drum removal Coagulation/flocculation, adsorption, evaporation, distillation Neutralization, oxidation, reduction, photolysis Aerobic/anaerobic biological treatment, biotechnologies Incineration, pyrolysis, co-disposal
Sludges	For Human Health: Prevent direct contact with sludge having [carcinogen(s)] in excess of 10^{-4} to 10^{-7} excess cancer risk. Prevent ingestion/contact with sludge having [non-carcinogen(s)] in excess of [reference dose(s)].	No Action/Institutional Actions: No action Access restrictions to [location] Containment Actions: Containment Removal/Treatment Actions: Removal/disposal	No Action/Institutional Options: Fencing Deed restrictions Containment Technologies: Vertical barriers Horizontal barriers Removal Technologies: Bulk sludge removal Drum removal Treatment Technologies: Solidification, fixation	 Slurry wall, sheet piling Liners Semi-solid excavation, pumping Drum removal Sorption, pozzolanic agents, encapsulation

TABLE 4-1
(continued)

Environmental Media	Remedial Action Objectives (from site characterization)	General Response Actions (for all remedial action objectives)	Remedial Technology Types (for general response actions)	Process Options
Sludges (continued)	Prevent migration of [carcinogen(s)] which would result in ground water concentrations in excess of 10^{-4} to 10^{-7} excess cancer risk. For Environmental Protection: Prevent releases of [contaminant(s)] from sludge that would result in surface water levels in excess of [ambient water quality criteria]. Prevent releases of [contaminant(s)] from sludge that would result in ground water levels of [contaminant(s)] in excess of [concentration(s)].	Removal/treatment/disposal	Physical treatment Chemical treatment Biological treatment Thermal treatment (organics) Dewatering Disposal Technologies: Product reuse Landfilling (after treatment)	Presse crystallization, neutralization, oxidation, electrochemical reduction Oxidation, reduction, photolysis Aerobic/anaerobic treatment, land treatment new biotechnologies Incineration, pyrolysis, co-disposal Gravity thickening, belt filter press, vacuum filtration

Acceptable exposure levels for human health should be determined on the basis of the risk factors and contaminant-specific ARARs identified during the site characterization. Contaminant levels in each media should be compared with these acceptable levels. Acceptable exposure levels should be determined on the basis of an evaluation of the following factors:

- For carcinogens, whether the chemical-specific ARAR provides protection within the risk range of 10^{-4} to 10^{-7} and whether achievement of each chemical-specific ARAR will sufficiently reduce the total risk from exposure to multiple chemicals

- For non-carcinogens, whether the chemical-specific ARAR is sufficiently protective if multiple chemicals are present at the site

- Whether environmental effects (in addition to human health effects) are adequately addressed by the ARARs

- Whether the ARARs adequately address all significant pathways of human exposure identified in the baseline risk assessment. For example, if the exposure from the ingestion of fish and drinking water are both significant pathways of exposure, application of an ARAR that is based only on drinking water ingestion (e.g., MCLs) may not be adequately protective.

If an ARAR is determined to be protective, it should be used to establish the acceptable exposure level. If an ARAR is not protective (i.e., presents a risk greater than 10^{-4}), does not exist for the specific chemical or pathways of concern, or multiple contaminants may be posing a cumulative risk, acceptable exposure levels should be identified through the risk assessment process. The Superfund Public Health Evaluation Manual provides additional details on establishing acceptable exposure levels when no ARARs exist.

4.2.2 Develop General Response Actions

General response actions describe those actions that will satisfy the remedial action objectives. These may include treatment, containment, excavation, extraction, disposal, institutional actions, or a combination of these. Like remedial action objectives, general response actions are medium-specific.

General response actions that might be taken at a site are initially defined during scoping and are refined throughout the RI/FS as a better understanding of site conditions is gained and action-specific ARARs are identified. In developing alternatives, combinations of general actions may be identified, particularly when disposal methods are strongly dependent on whether the medium has been previously treated. Examples of potential general response actions are included in column three of Table 4-1.

4.2.3 Identify Volumes or Areas of Media

During development of alternatives an initial determination is made of areas or volumes of media to which general response actions might be applied. This initial determination is made for each medium of interest on a site. Response actions for areas or volumes of media are often refined after sitewide alternatives have been assembled to take interactions between media into account. The refinement of alternatives is discussed at greater length in Chapter 5 of this guidance document.

Defining the areas or volumes of media requires careful judgment and should include a consideration of not only acceptable contaminant levels and exposure routes, but also site conditions and the nature and extent of contamination. For example, in an area with contamination that is homogeneously distributed in a medium, discrete risk levels (e.g., 10^{-5}, 10^{-6}) or corresponding contaminant levels may provide the most rational basis for defining areas or volumes of media to which

treatment, containment, or excavation actions may be applied, as illustrated in Figure 4-4A.

For sites with discrete hot spots or areas of more concentrated contamination, however, it may be more useful to define areas and volumes for remediation on the basis of the site-specific relationship of volume (or area) to contaminant level, as shown in Figure 4-4B. Therefore, when areas or volumes of media are defined on the basis of site-specific considerations such as volume versus concentration relationships, the volume or area addressed by the alternative should be reviewed with respect to the remedial action objectives to ensure that alternatives can be assembled to, as a minimum, reduce exposure to protective levels.

4.2.4 Identify and Screen Remedial Technologies and Process Options

In this step, the universe of potentially applicable technology types and process options is reduced by evaluating the options with respect to technical implementability. In this guidance document, the term "technology types" refers to general categories of technologies, such as chemical treatment, thermal destruction, solidification, capping, or dewatering. The term "technology process options" refers to specific processes within each technology type. For example, the chemical treatment technology type would include such process options as precipitation, ion exchange, and oxidation/reduction. As shown in columns four and five of Table 4-1, several broad technology types may be identified for each general response action, and numerous technology process options may exist within each technology type.

Technology types and process options may be identified by drawing on a variety of sources including references developed for application to Superfund sites and more standard engineering texts not specifically directed toward hazardous waste sites. Some of these sources are included in Appendix C of this document.

FIGURE 4-4A. POTENTIAL GENERAL RESPONSE SCENARIOS FOR AN AREA WITH HOMOGENEOUSLY DISTRIBUTED CONTAMINATION

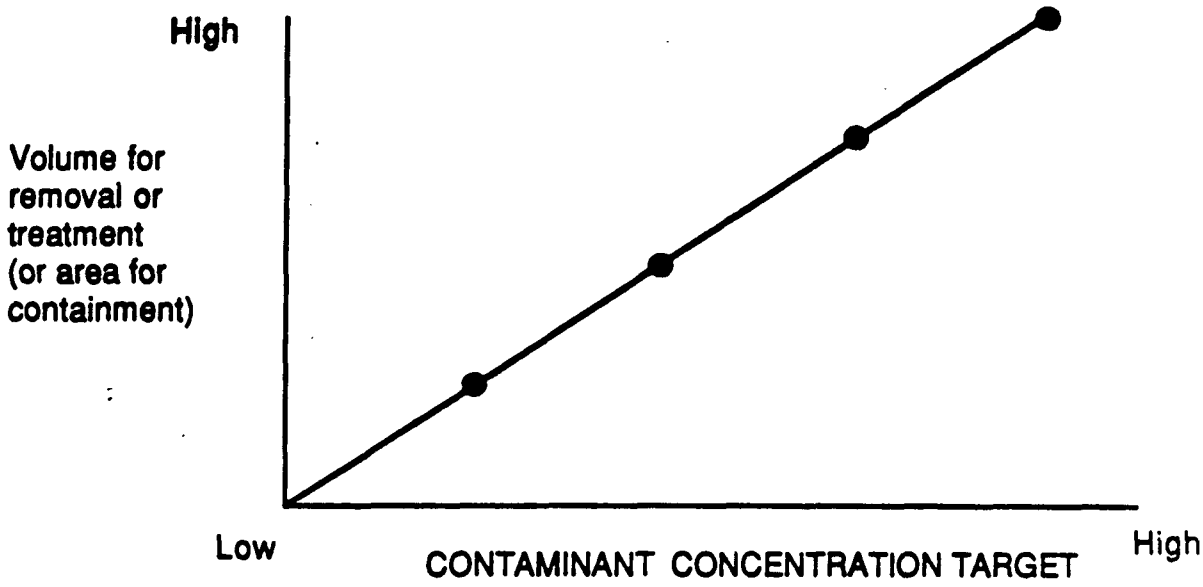
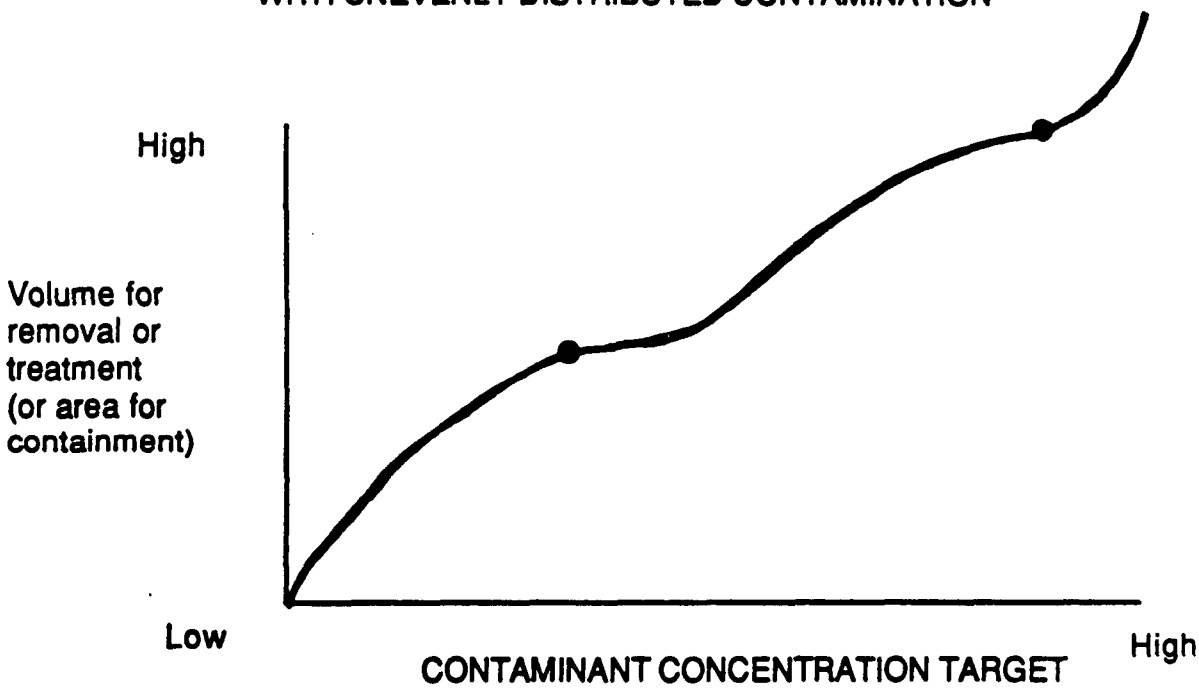


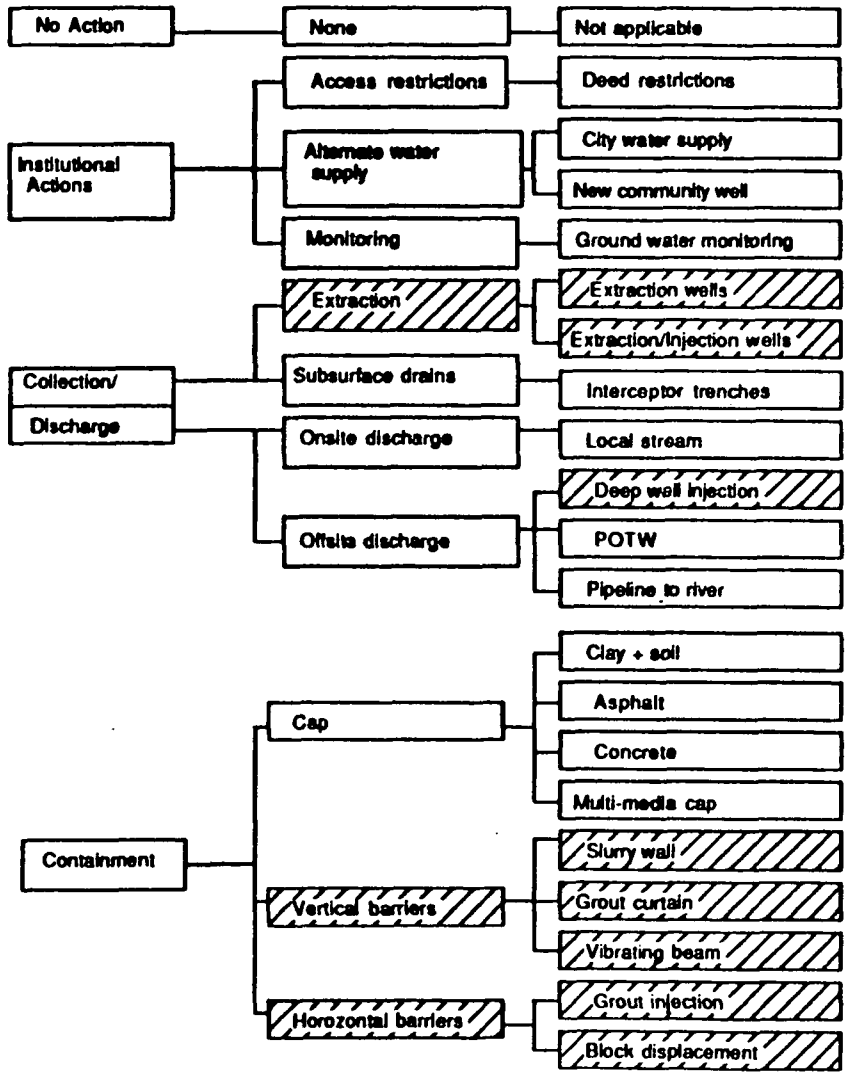
FIGURE 4-4B. POTENTIAL GENERAL RESPONSE SCENARIOS FOR AN AREA WITH UNEVENLY DISTRIBUTED CONTAMINATION



● Potential General Response Action Level

FIGURE 4-5

AN EXAMPLE OF INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS



Ground Water General Response Actions	Remedial Technology	Process Options	Description	Screening Comments
No Action	None	Not applicable	No action	Required for consideration by NCP.
Institutional Actions	Access restrictions	Deed restrictions	Deeds for property in the area of influence would include restrictions on wells.	Potentially applicable.
	Alternate water supply	City water supply	Extension of existing municipal well system to serve residents in the area of influence.	Potentially applicable.
		New community well	New uncontaminated wells to serve residents in the area of influence.	Potentially applicable.
	Monitoring	Ground water monitoring	Ongoing monitoring of wells.	Potentially applicable.
Collection/ Discharge	Extraction	Extraction wells	Series of wells to extract contaminated ground water.	Not feasible for intercepting contaminants in fractured bedrock.
		Extraction/Injection wells	Injection wells inject uncontaminated water to increase flow to extraction wells.	Not feasible for intercepting contaminants in fractured bedrock.
	Subsurface drains	Interceptor trenches	Perforated pipe in trenches backfilled with porous media to collect contaminated water.	Potentially applicable.
	Onsite discharge	Local stream	Extracted water discharged to stream on the site.	Potentially applicable.
	Offsite discharge	Deep well injection	Extracted water discharged to deep well injection system.	Deep aquifer not suitable for injection of contaminants.
		POTW	Extracted water discharged to local POTW for treatment.	Potentially applicable.
		Pipeline to river	Extracted water discharged to river offsite.	Potentially applicable.
Containment	Cap	Clay + soil	Compacted clay covered with soil over areas of contamination	Potentially applicable.
		Asphalt	Spray application of a layer of asphalt over areas of contamination.	Potentially applicable.
		Concrete	Installation of a concrete slab over areas of contamination.	Potentially applicable.
		Multi-media cap	Clay and synthetic membrane covered by soil over areas of contamination.	Potentially applicable.
	Vertical barriers	Slurry wall	Trench around areas of contamination is filled with a soil (or cement) bentonite slurry.	Not feasible because of very shallow depth to bedrock.
		Grout curtain	Pressure injection of grout in a regular pattern of drilled holes.	Not effective because of fractured bedrock.
		Vibrating beam	Vibrating force to advance beams into the ground with injection of slurry as beam is withdrawn.	Not feasible because of very shallow depth to bedrock.
	Horozontal barriers	Grout injection	Pressure injection of grout at depth through closely spaced drilled holes.	Not effective because of fractured bedrock.
		Block displacement	In conjunction with vertical barriers, injection of slurry in notched injection holes.	Not feasible because of very shallow depth to bedrock.

Legend ▨ - Technologies that are screened out

During this screening step, process options and entire technology types are eliminated from further consideration on the basis of technical implementability. This is accomplished by using readily available information from the RI site characterization on contaminant types and concentrations and onsite characteristics to screen out technologies and process options that cannot be effectively implemented.

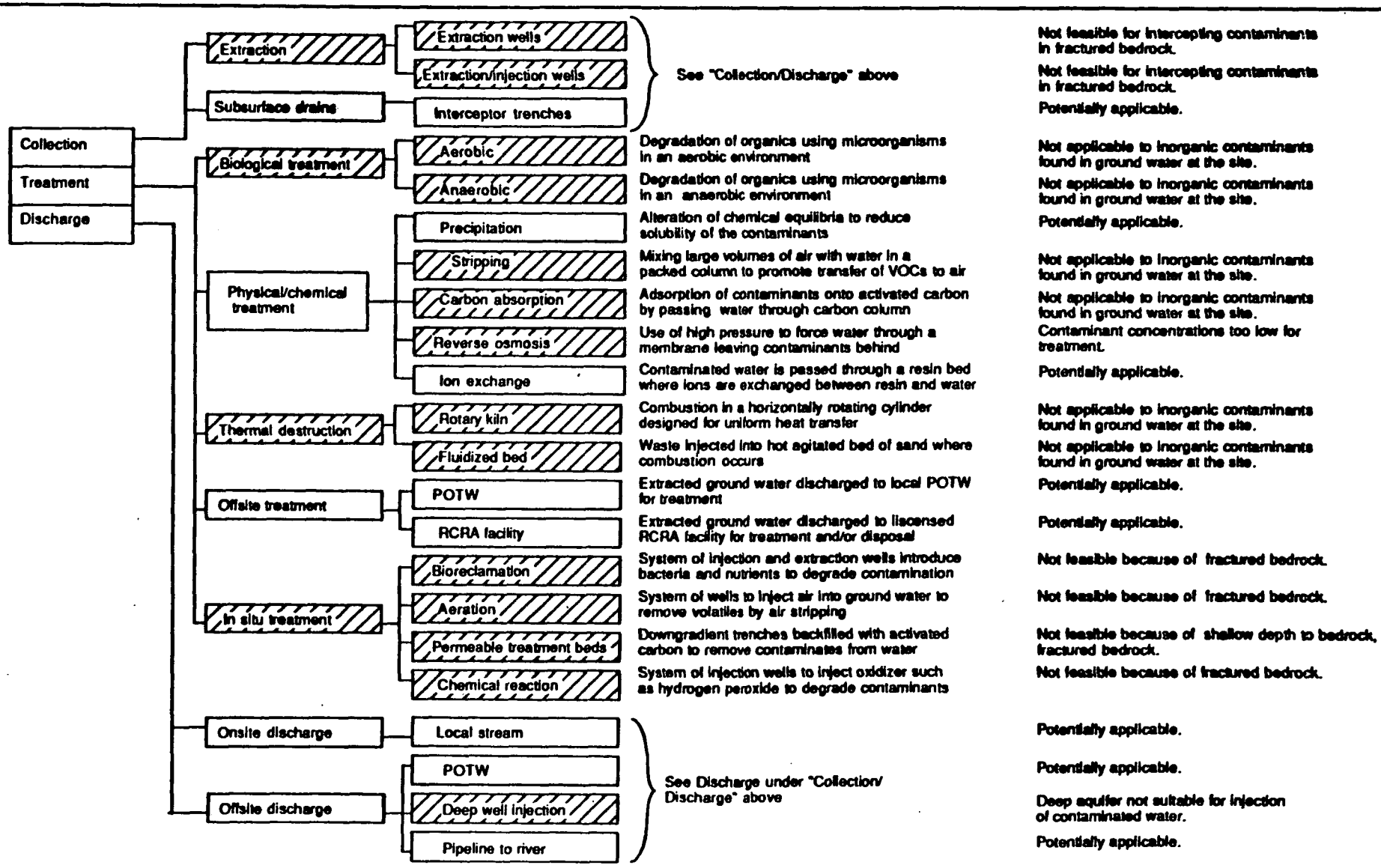
Two factors that commonly influence technology screening are the presence of inorganic contaminants, which limit the applicability of many types of treatment processes, and the subsurface conditions, such as depth to impervious formations or the degree of fracture in bedrock, which can limit many types of containment and ground-water collection technologies. This screening step is site-specific, however, and other factors may need to be considered. Figure 4-5 provides an example of initial technology screening for ground-water remediation at a site having organic and inorganic contaminants and shallow, fractured bedrock.

As with all decisions during an RI/FS, the screening of technologies should be documented. For most studies, a figure similar to Figure 4-5 provides adequate information for this purpose and can be included in the FS report.

4.2.5 Evaluate Process Options

In the fourth step of alternative development, the technology processes considered to be implementable are evaluated in greater detail before selecting one process to represent each technology type. One representative process is selected, if possible, for each technology type to simplify the subsequent development and evaluation of alternatives without limiting flexibility during remedial design. The representative process provides a basis for developing performance specifications during preliminary design; however, the specific process actually used to implement the remedial action at a site may not be selected until the remedial design phase. In some cases more than one

FIGURE 4-5 (continued)



process option may be selected for a technology type. This may be done if two or more processes are sufficiently different in their performance or effect that one would not adequately represent the other.

Process options are evaluated using the same criteria--effectiveness, implementability, and cost--that is used to screen alternatives prior to the detailed analysis. An important distinction to make is that at this time these criteria are applied only to technologies and the general response actions they are intended to satisfy--and not to the site as a whole. Furthermore, the evaluation should typically focus on effectiveness factors at this stage with less effort directed at the implementability and cost evaluation.

Because of the limited data on innovative technologies, it may not be possible to evaluate these process options on the same basis as other demonstrated technologies. Typically, if innovative technologies are judged to be implementable they are retained for evaluation either as a "selected" process option (if available information indicates that they will provide better treatment, fewer or less adverse effects, or lower costs than other options), or they will be "represented" by another process option of the same technology type. The evaluation of process options is illustrated in Figure 4-6 and discussed in more detail below.

4.2.5.1 Effectiveness Evaluation

Specific technology processes that have been identified should be evaluated further on their effectiveness relative to other processes within the same technology type. This evaluation should focus on: 1) the potential effectiveness of process options in handling the estimated areas or volumes of media and meeting the contaminant reduction goals identified in the general response actions;[1]

[1] the ability of some collection/removal systems, such as ground-water pumping, to sufficiently recover contaminated media for subsequent treatment may also be assessed as part of this evaluation.

[redacted]URE[redacted]

AN EXAMPLE OF THE EVALUATION OF PROCESS OPTIONS

Ground Water General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost
No Action	None	Not applicable	* Does not achieve remedial action objectives	Not acceptable to local/ public government.	None.
Institutional Actions	Access restrictions	Deed restrictions	Effectiveness depends on continued future implementation. Does not reduce contamination..	Legal requirements.	Negligible cost.
	Alternate water supply	City water supply	* Effective in preventing use of contaminated ground water. No contaminant reduction.	Conventional construction, requires local approvals.	High capital, low O&M.
		New community well	Effective in preventing use of contaminated ground water. No contaminant reduction.	Conventional construction, requires local approvals.	High capital, low O&M.
	Monitoring	Ground water monitoring	* Useful for documenting conditions. Does not reduce risk by itself.	Alone, not acceptable to public/ local government.	Low capital, low O&M.
Collection/ Discharge	Subsurface drains	Interceptor trenches	* Effective for downgradient fracture flow interception.	Very difficult to implement -- requires deep trenching through rock.	Very high capital, low O&M.
	Onsite discharge	Local stream	* Effective and reliable discharge method. Does not eliminate contamination.	Discharge permits required.	Low capital, very low O&M.
	Offsite discharge	POTW	* Effective and reliable discharge method. Does not eliminate contamination.	Discharge permits required.	High capital, low O&M.
		Pipeline to river	Effective and reliable discharge method. Does not eliminate contamination.	Discharge permits required.	High capital, low O&M.
Containment	Cap	Clay + soil	* Effective, susceptible to cracking, but has self-healing properties.	Easily implemented. Restrictions on future land use.	Low capital, low maintenance.
		Asphalt	Effective but susceptible to weathering and cracking.	Easily implemented. Restrictions on future land use.	Low capital, high maintenance.
		Concrete	Effective but susceptible to weathering and cracking.	Easily implemented. Restrictions on future land use.	Moderate capital, high maintenance.
		Multi-media cap	Effective, least susceptible to cracking.	Easily implemented. Restrictions on future land use.	Moderate capital, mod. maintenance.
Collection/ Treatment/ Discharge	Subsurface drains	Interceptor trenches	* Effective for downgradient fracture flow interception.	Very difficult to implement--re - quires deep trenching through rock.	Very high capital, low O&M.
	Physical/chemical treatment	Precipitation	* Effective and reliable; conventional technology. Requires sludge disposal.	Readily implementable.	High capital, moderate O&M.
		Ion exchange	Effective and reliable; proper pretreatment required.	Readily implementable.	High capital, high O&M.
	Offsite treatment	POTW	Effectiveness and reliability require pilot test to determine.	Readily implementable, permit required.	Moderate capital, low O&M.
		RCRA facility	Effective and reliable treatment; transportation required.	Nearest RCRA facility 250 miles away.	High transportation cost.
	Onsite discharge	Local stream	* Effective and reliable.	Readily implementable, Permit required.	Low capital, very low O&M.
	Offsite discharge	POTW	* Effective and reliable.	Permit required.	High capital, low O&M.
		Pipeline to river	Effective and reliable.	Permit required.	High capital, low O&M.

* Selected representative technologies

2) the effectiveness of the process options in protecting human health and the environment during the construction and implementation phase; and 3) how proven and reliable the process is with respect to the contaminants and conditions at the site.

Information needed to evaluate the effectiveness of technology types for the different media includes contaminant type and concentration, the area or volume of contaminated media, and, when appropriate, rates of collection of liquid or gaseous media. For some media it may be necessary to conduct preliminary analyses or collect additional site data to adequately evaluate effectiveness. This is often the case for processes in which the rates of removal or collection and treatment are needed for evaluation, such as for ground-water extraction, surface-water collection treatment, or subsurface gas collection. In such cases, a limited conceptual design of the process may need to be developed, and modeling of the potential environmental transport mechanisms associated with their operation may be undertaken. Typically, however, such analyses are conducted during the later phases of the FS when alternatives are refined and evaluated on a sitewide basis.

If modeling of transport processes is undertaken (during either the alternative development or screening phases of the FS) to evaluate removal or collection technologies, and if many contaminants are present at the site, it may be necessary to identify indicator chemicals, as is sometimes done for risk assessments, to simplify the analysis. Typically, indicator chemicals are selected on the basis of their usefulness in evaluating potential effects on public health and the environment. Commonly selected indicator chemicals include those that are most mobile and most toxic. The Superfund Public Health Evaluation Manual contains more information on selecting indicator chemicals.

4.2.5.2 Implementability Evaluation

Implementability encompasses both the technical and institutional feasibility of implementing a technology process. As discussed in Section 4.2.4, technical implementability is used as an initial screen of technology types and process options to eliminate those that are clearly ineffective or unworkable at a site. Therefore, this subsequent, more detailed evaluation of process options places greater emphasis on the institutional aspects of implementability, such as the ability to obtain necessary permits for offsite actions, the availability of treatment, storage, and disposal services (including capacity), and the availability of necessary equipment and skilled workers to implement the technology.

4.2.5.3 Cost Evaluation

Cost plays a limited role in the screening of process options. Relative capital and O&M costs are used rather than detailed estimates. At this stage in the process, the cost analysis is based on engineering judgment, and each process is evaluated as to whether costs are high, low, or medium relative to other process options in the same technology type. As discussed in Chapter 5, "Screening of Alternatives," the greatest cost consequences in site remediation are usually associated with the degree to which different general technology types (i.e., containment, treatment, excavation, etc.) are used. Using different process options within a technology type usually has a lesser effect on cost.

4.2.6 Assemble Alternatives

In assembling alternatives, general response actions and the process options chosen to represent the various technology types for each medium or operable unit are combined to form alternatives for the site as a whole. As discussed in Section 4.1.2.2, appropriate treatment and containment options should be developed. To assemble alternatives,

general response actions should be combined using different technology types and different volumes of media and/or areas of the site. Often more than one general response action is applied to each medium. For example, alternatives for remediating soil contamination will depend on the type and distribution of contaminants and may include incineration of soil from some portions of the site and capping of others.

For sites at which interactions among media are not significant (i.e., source control actions will not affect ground-water or surface-water responses) the combination of medium-specific actions into sitewide alternatives can be made later in the FS process, either after alternatives have been screened or the detailed analysis has been completed. If media interactions are not of concern, the FS may, for example, describe three soil remediation options, four ground-water remediation options, and three remediation of contaminated structures (instead of developing 36 sitewide alternatives). These 10 medium-specific options could be screened in the following FS phase and evaluated during detailed analysis prior to being combined into sitewide alternatives. Although this approach permits greater flexibility in developing alternatives and simplifies the analyses of sitewide alternatives, it may involve greater effort in developing and analyzing medium-specific options.

Figure 4-7 illustrates how general response actions may be combined to form a range of sitewide alternatives. For this relatively simple example, the two media of interest are soil and ground water. The range of alternatives developed include: a no-action alternative (alternative 1); an alternative that provides for treatment of all soil contaminants to the 10^{-6} risk level and rapid remediation of ground water to 10^{-6} risk level (alternative 2); three alternatives that employ treatment of soil and ground water to various risk levels with different disposal options (alternatives 3, 4, and 5); and three alternatives that employ various levels of containment, with and without ground-water collection and treatment (alternatives 6, 7, and 8).

Although not shown in this example, a description of each alternative should be included in the FS report. For the alternatives shown in Figure 4-7, such descriptions would include the locations of areas to be excavated or contained, the approximate volumes of soil and/or ground water to be excavated and collected, the approximate locations of interceptor trenches, the locations of potential city water supply hook-ups, the locations of potential discharges to surface water or connections to the local POTW, management options for treatment residuals, and any other information needed to adequately describe the alternative and document the logic behind the assembly of general response actions into specific remedial action alternatives. In describing alternatives, it is important to note those process options that were not screened out and that are represented by those described in the alternative.

4.3 COMMUNITY RELATIONS DURING ALTERNATIVE DEVELOPMENT

Community relations activities implemented for site characterization may also be appropriate during the development of alternatives. Activities focus on providing information to the community concerning the development of remedial alternatives and obtaining feedback on community interests and concerns associated with such alternatives. Community relations activities should be site- and community-specific and are usually stipulated in the community relations plan that is prepared during scoping activities. Community relations activities during the development of alternatives may include, but are not limited to, a fact sheet describing alternatives identified as potentially feasible, a workshop presenting citizens with Agency considerations in developing alternatives, briefings of local officials and concerned citizens on alternatives under consideration, a small group meeting for citizens involved with the site, and news releases describing technologies being evaluated.

If alternatives are being developed concurrently with the RI site characterization, then information on the screening of technologies and remedial alternative development should be included in public

FIGURE 4-7

ASSEMBLING A RANGE OF ALTERNATIVE EXAMPLES

GENERAL RESPONSE ACTION			1	2	3	4	5	6	7	8
			NO ACTION	NO LONG-TERM SOURCE MANAGEMENT NEEDED, RAPID GW CLEAN-UP	TREATMENT AS A PRINCIPAL ELEMENT (10^{-6})	TREATMENT AS A PRINCIPAL ELEMENT (10^{-4})	TREATMENT AS A PRINCIPAL ELEMENT	SOURCE CONTAINMENT GW CONTROLS	SOURCE CONTAINMENT NO GW CONTROLS	CONTAINMENT (MINIMUM)
MEDIUM	TECHNOLOGY TYPE	AREA OR VOLUME								
SOIL	ACCESS RESTRICTIONS (FENCING)	ENTIRE SITE	●							
	EXCAVATION	ALL SOIL ABOVE 10^{-6}		●	●					
		ALL SOIL ABOVE 10^{-4}				●	●	●	●	
	DISPOSAL	ONSITE RCRA LANDFILL				●		●	●	
		ONSITE NON-RCRA LANDFILL			●		●			
		OFFSITE RCRA LANDFILL		●						
	TREATMENT ONSITE	ALL SOIL TO 10^{-6}			●					
		ALL SOIL TO 10^{-4}				●	●			
	TREATMENT OFFSITE			●						
	CAPPING	ENTIRE SITE								●
		ALL (REMAINING) SOIL ABOVE 10^{-6}				●		●	●	
GROUNDWATER	ALTERNATE WATER SUPPLY	ALL RESIDENTS IN AFFECTED AREA							●	●
	MONITORING	ALL MONITORING WELLS TWICE A YEAR	●	●	●	●	●	●	●	●
	COLLECTION WITH INTERCEPTOR TRENCHES	ALL WATER ABOVE 10^{-6} WITHIN 10 YRS	●		●					
		ALL WATER ABOVE 10^{-4} WITHIN 10 YRS		●		●		●		
		ALL WATER ABOVE 10^{-6} WITHIN 30 YRS					●			
	TREATMENT WITH PRECIPITATION ONSITE	TO 10^{-6}		●						
		TO 10^{-4}				●	●			
	DISCHARGE	ONSITE TO LOCAL STREAM		●	●		●			
		OFFSITE TO POTW				●		●		

Note: This is a conceptual example using the example of carcinogenic risk ranges; however, in general, when MCLs are available they will apply.

information materials and activities prepared during site characterization. If alternatives are developed after site characterization, additional community relations activities should be conducted. In general, community relations activities during alternative development are most appropriate if citizens are significantly concerned over site conditions and RI/FS activities which are being implemented at the site. The following are objectives of community relations activities at this phase:

- Keep the community apprised of the Agency's decisionmaking process

- Enhance citizen understanding of issues pertaining to development, evaluation, and selection of remedial alternatives

- Obtain feedback from the community on any concerns they may have with technologies and alternatives under consideration

The level of effort for community relations at this phase should be described in the community relations plan.

4.4 REPORTING AND COMMUNICATION DURING ALTERNATIVE DEVELOPMENT

No formal report preparation is required during alternative development except whatever routine administrative and project management tracking methods have been designated for use by the lead agency and their contractor(s). However, communication among the lead and support agencies and their contractor(s) is very important during the development of alternatives to obtain input and agreement on the technologies or processes and alternatives considered for implementation at the site. As shown in Table 4-2, communication should occur to facilitate the initial screening of technologies and process options, to agree on what additional site data may be needed, and to gain input and agreement on the choice of representative processes and combinations

to be used to assemble alternatives. For purposes of speed and efficiency, the preferred approach for the exchange of information is through meetings. However, other approaches that facilitate effective review and input (e.g., technical memorandums for review) may be used at the lead agency's discretion.

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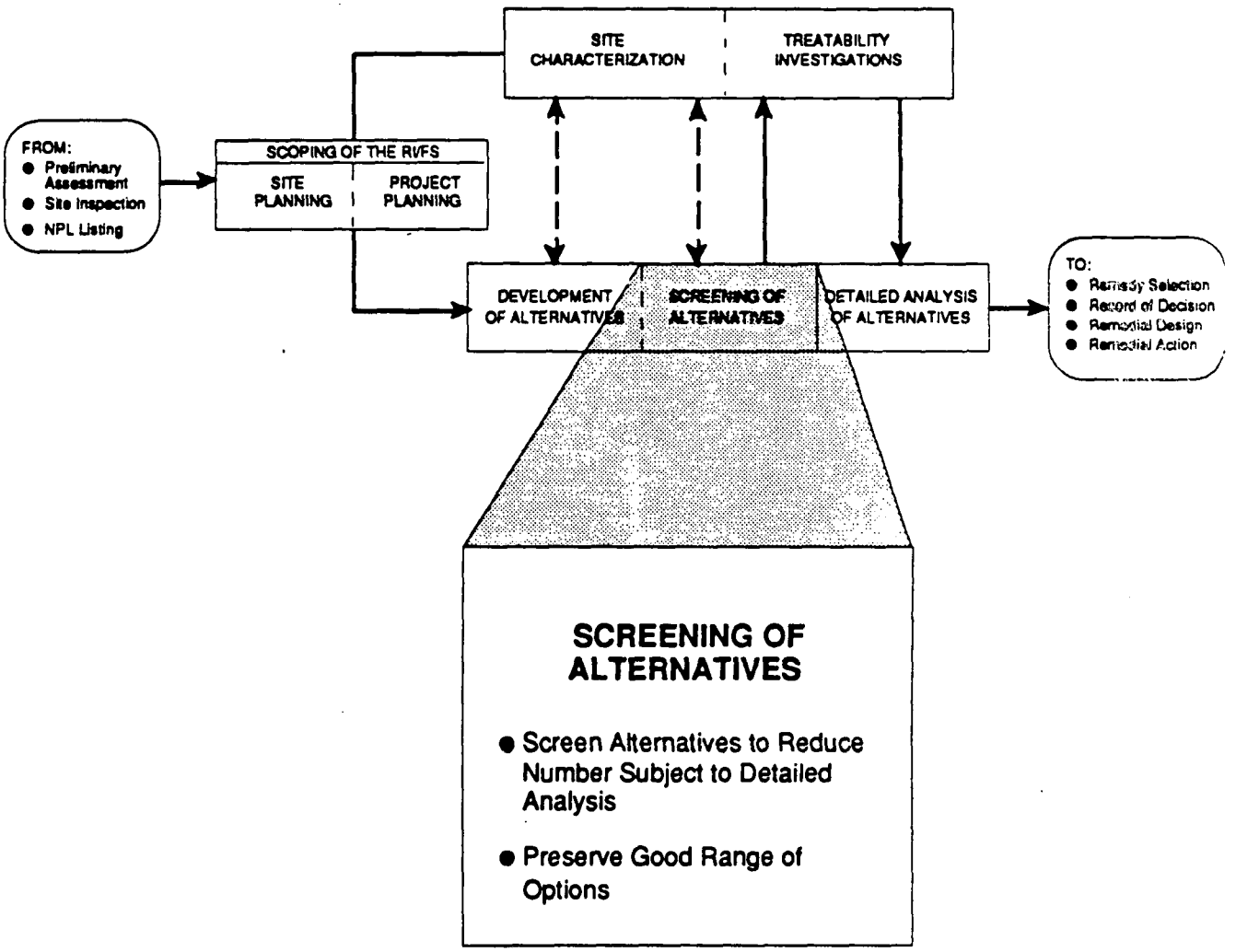
Table 4-2
REPORTING AND COMMUNICATION DURING ALTERNATIVE DEVELOPMENT

Information Needed	Purpose	Potential Methods for Information Provision
All potential technologies included for consideration	For lead agency and contractor to identify potential technologies; for lead agency to obtain support agency review and comment	1 - Meeting 2 - Tech Memo 3 - Other
Need for additional field data or treatability studies	For lead agency and contractor to determine whether more field data or treatability tests are needed to evaluate selected technologies; for lead agency to obtain support agency review and comment	1 - Meeting 2 - Tech Memo 3 - Other
Process evaluation and alternative development	For lead agency and contractor to communicate and reach agreement on technology screening and alternative development; for lead agency to obtain support agency review and comment	1 - Meeting 2 - Tech Memo 3 - Other

WDR276/014

CHAPTER 5
FS PHASE II
SCREENING OF ALTERNATIVES



CHAPTER 5
SCREENING OF ALTERNATIVES

5.1 INTRODUCTION

5.1.1 Purpose of Alternative Screening

The objective of alternative screening is to narrow the list of potential alternatives (based on their effectiveness, implementability, and cost) that will be evaluated in detail. This screening aids in streamlining the feasibility study process while ensuring that the most promising alternatives are being considered. As discussed earlier, in some situations the number of viable alternatives to address site problems may be limited; thus, the screening effort may be minimized or unecessary.

Screening is used as a tool throughout the alternative development process to narrow the universe of options being considered. When alternatives are first being developed, individual technologies are screened primarily on their ability to meet medium-specific remedial action objectives, as well as with respect to their implementability and cost. The remaining technologies are then assembled into alternatives designed to meet the remedial action objectives developed for the site or operable unit. Dependent on the number of viable alternatives initially developed, the list of potential alternatives may need to be screened to reduce the number of alternatives that will be analyzed in detail. While screening alternatives, the range of treatment and containment alternatives initially developed should be preserved to the extent it makes sense to do so.

5.1.2 Context of Screening

The screening of alternatives follows the conceptual development of alternatives and precedes the detailed analysis of alternatives. Prior to screening, technologies should be identified and combined into alternatives, although specific details of the alternatives may not be defined. During screening, the extent of remedial action (e.g., quantities of media to be affected), the sizes and capacities of process options, and other details of each alternative should be further defined, as necessary, so that screening evaluations can be conducted. Because the FS may be comprised of many complex, interrelated, and overlapping steps, the boundaries between the FS phases, as described here, are often less distinct in actual practice. This three phased discussion of the FS is used primarily to help portray more simply the overall process.

The scope of screening can vary substantially depending on the number and type of alternatives developed and the extent of information necessary for conducting the detailed analysis. The scope and emphasis of screening can also vary depending on either the degree to which the assembled alternatives address the combined threats posed by the entire site or on the individual threats posed by separate site areas or contaminated media.

5.1.3 Screening Process Overview

Three distinct steps are typically conducted during the screening of alternatives. First, the alternatives are further refined as appropriate. Second, the alternatives are evaluated on a general basis to determine their effectiveness, implementability, and cost. Third, a decision is made, based on this evaluation, as to which alternatives should be retained for further analysis.

Alternatives are further refined by better quantifying the areas and volumes of media of interest and the sizes and capacities of the process options that make up each of the alternatives. During this phase, the remedial action objectives developed earlier for each medium

or operable unit are revised as necessary to incorporate any new risk assessment information being generated from the RI to ensure that the alternatives provide adequate protectiveness. Also at this stage, the areas and quantities of contaminated media initially specified in the general response actions may also be reevaluated with respect to the effects of interactions between media. Often, source control actions influence the degree to which ground-water remediation can be accomplished or the time frame in which it can be achieved. In such instances, further analyses may be conducted to modify either the source control or ground-water response actions to achieve greater cost-effectiveness in sitewide alternatives.

Using the refined alternative configurations developed above, more detailed information about the technology process options may be developed. This information might include data on the size and capacities of treatment systems, the quantity of materials required for construction, and the configuration and design requirements for ground-water collection systems.

Information available at the time of screening should be used primarily to identify and distinguish any differences among the various alternatives and evaluate each alternative with respect to its effectiveness, implementability, and cost.[1] Only the alternatives judged as the best or most promising on the basis of these evaluation factors should be retained for further consideration and analysis. Typically, those alternatives that are screened out will receive no further consideration unless additional information becomes available that indicates further evaluation is warranted. As discussed in Section 4.2.6, for sites at which interactions among media are not significant, the process of screening alternatives, described here, may be applied to medium-specific options to reduce the number of options that will either be

[1] It is important to avoid confusion between the screening of technologies done during the development of alternatives (see Section 4.2.4) and the screening of alternatives described in this Chapter.

combined into sitewide alternatives at the conclusion of screening or will await further evaluation in the detailed analyses. The screening of alternatives is shown conceptually in Figure 5-1.

5.2 ALTERNATIVES SCREENING PROCESS

5.2.1 Alternatives Definition

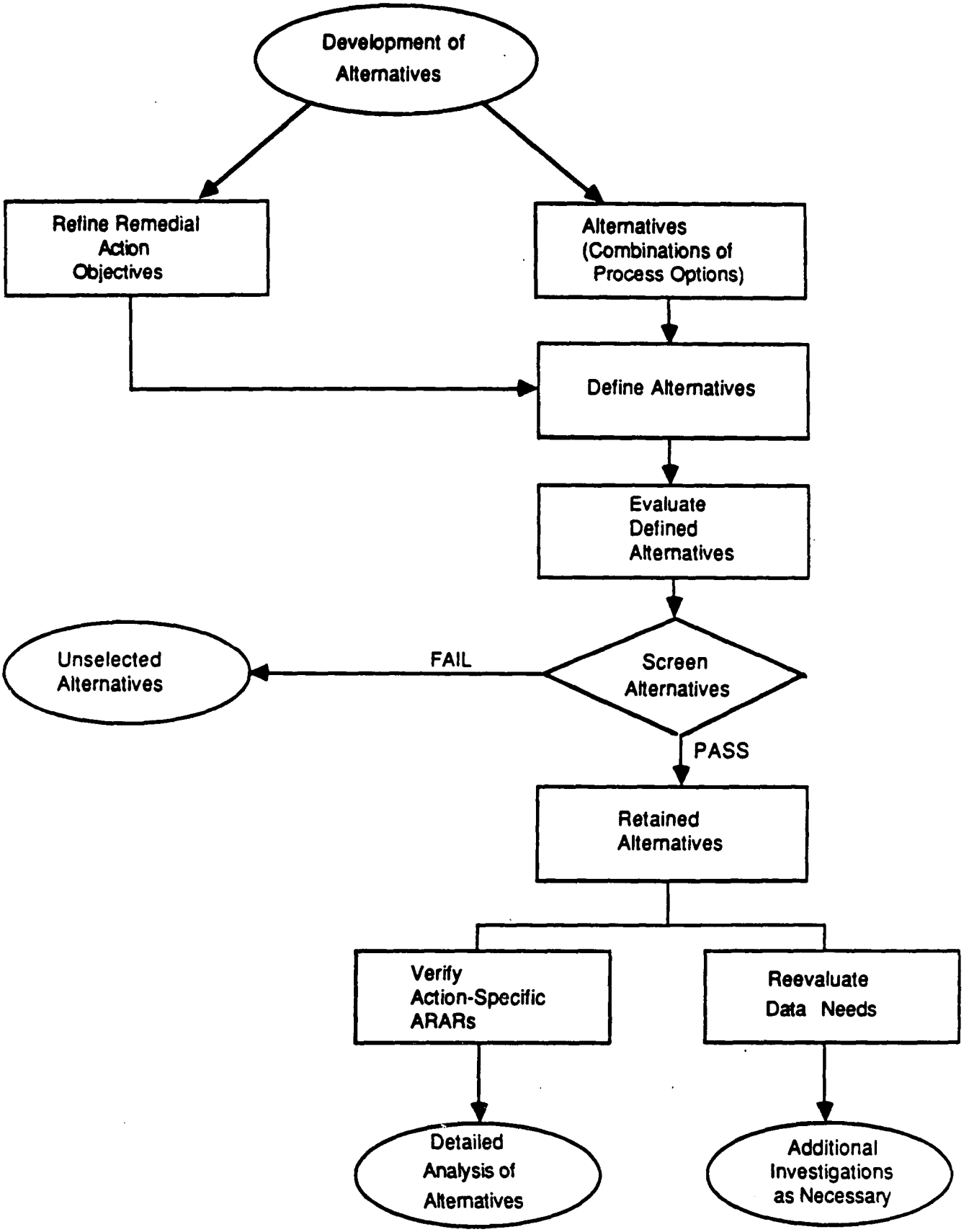
Before beginning screening, alternatives have been assembled primarily on medium-specific considerations and implementability concerns. Typically, few details of the individual process options have been identified, and the sizing requirements of technologies or remediation time frames have not been fully characterized (except for time frames identified to develop ground-water action alternatives). Furthermore, interactions among media, which may influence remediation activities, have usually not been fully determined, nor have sitewide protectiveness requirements been addressed. Therefore, at this point in the process, such aspects of the alternatives must be further defined to form the basis for evaluating and comparing the alternatives prior to their screening.

5.2.1.1 Specific Objectives

Alternatives are initially developed and assembled to meet a set of remedial action objectives for each medium of interest. During screening, the assembled alternatives should be evaluated to ensure that they protect human health and the environment from all potential pathways at the site or those areas of the site being addressed as part of an operable unit. If more than one pathway is present, such as inhalation of airborne contaminants and ingestion of contaminants in ground water, the overall risk level to receptors should be evaluated. If it is found that an alternative is not fully protective, a reduction in exposure levels for one or more media will need to be made to attain a risk level within the target range (i.e., 10^{-4} to 10^{-7}).

FIGURE 5-1

SCREENING OF ALTERNATIVES



In refining alternatives, it is important to note that protectiveness is achieved by reducing exposures to acceptable levels, but achieving these reductions in exposures may not always be possible by actually cleaning up a specific medium to these same levels. For example, protectiveness of human health at a site may require that concentrations of contaminants in drinking water be reduced to levels that could not reasonably be achieved for the water supply aquifer; thus, protectiveness could be provided by preventing exposures with the use of a wellhead treatment system. The critical selection of how risk reductions are to be achieved is part of the risk management decisionmaking process.

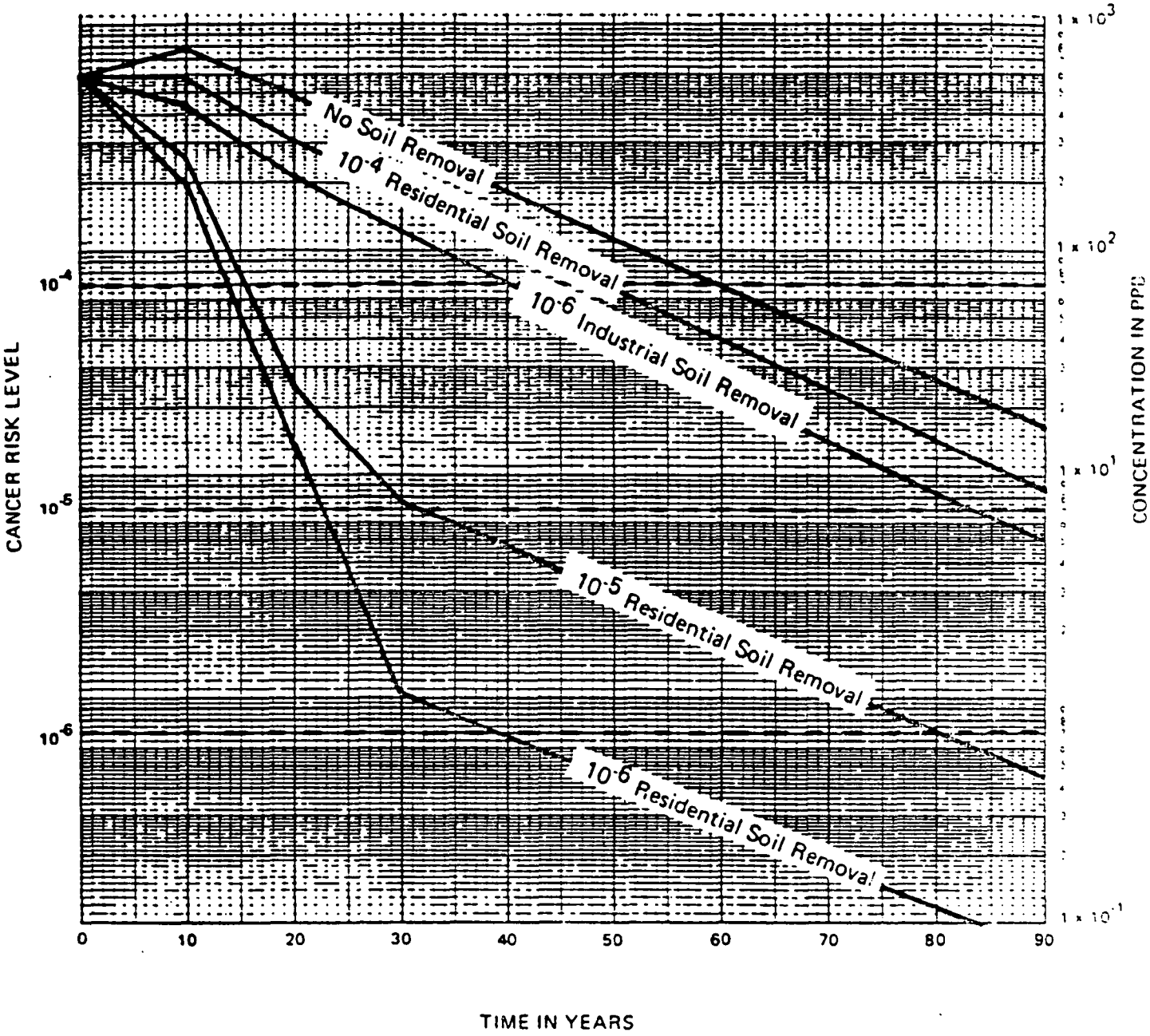
5.2.1.2 Define Media and Process Options

Alternatives should be defined to provide sufficient quantitative information to allow differentiation among alternatives with respect to effectiveness, implementability, and cost. Parameters that often require additional refinement include the extent or volume of contaminated material and the size of major technology and process options.

Refinement of volumes or areas of contaminated media is important at some sites at which ongoing releases from the source (or contaminated soils) significantly affect contaminant levels in other media (e.g., ground water), because such interactions may not have been addressed when alternatives were initially developed by grouping medium-specific response actions. If interactions among media appear to be important at a site, the effect of source control actions on the remediation levels or time frames for other media should be evaluated.

Figure 5-2 provides an example of such an analysis in which volatile organics in soil are migrating into an underlying aquifer composed of unconsolidated materials. Using a model of transport processes at the site, the effect of different soil removal actions on ground-water remediation (using a specified extraction scheme) could be estimated. In

FIGURE 5-2. TIME TO ACHIEVE 10^{-4} TO 10^{-6} RISK LEVEL FOR A SINGLE-CONTAMINANT FOR GROUNDWATER CLEANUP UNDER VARIOUS SOIL REMOVAL ALTERNATIVES



this example, development of alternatives that consider ground-water actions independent of soil removal (i.e., the no-soil-removal scenario) could result in underestimating the achievable remediation level or overestimating the time frame for ground-water remediation. This could result in an overestimation of the extraction and treatment requirements for technology processes for ground water. By evaluating soil-ground-water interactions together, the rates and volumes of ground-water extraction to achieve the target remediation levels can be refined more accurately.

After the alternatives have been refined with respect to volumes of media, the technology process options need to be defined more fully with respect to their effectiveness, implementability, and cost such that differences among alternatives can be identified. The following information should be developed, as appropriate, for the various technology processes used in an alternative:

- Size and configuration of onsite extraction and treatment systems or containment structures--For media contaminated with several hazardous substances, it may be necessary to first determine which contaminant(s) impose the greatest treatment requirements; then size or configure accordingly. Similarly, for ground-water extraction technologies at sites with multiple ground-water contaminants, it may be necessary to evaluate which compounds impose the greatest limits on extraction technologies, either because of their chemical/physical characteristics, concentration, or distribution in ground water.

- Time frame in which treatment, containment, or removal goals can be achieved--The remediation time frame is often interdependent on the size of a treatment system or configuration of a ground-water extraction system. The time frame may be based on specific remediation goals (e.g., attaining ground-water remediation goals in 10 years), in which case the technology is sized and configured to achieve this; the time frame may also be influenced by technological limitations (such as

maximum size consideration, performance capabilities, and/or availability of adequate treatment systems or disposal capacity).

- Rates or flows of treatment--These will also influence the sizing of technologies and time frame within which remediation can be achieved.

- Spatial requirements for constructing treatment or containment technologies or for staging construction materials or excavated soil or waste

- Distances for disposal technologies--These include approximate transport distances to acceptable offsite treatment and disposal facilities and distances for water pipelines for discharge to a receiving stream or a POTW.

- Required permits and imposed limitations--These include NPDES, pretreatment, and emission control requirements; coordination with local agencies and the public, and other legal considerations. These may also encompass some action-specific as well as location- and chemical-specific ARARs.

5.2.2 Screening Evaluation

Defined alternatives are evaluated against the short- and long-term aspects of three broad criteria: effectiveness, implementability, and cost. Because the purpose of the screening evaluation is to reduce the number of alternatives that will undergo a more thorough and extensive analysis, alternatives will be evaluated more generally in this phase than during the detailed analysis. However, evaluations at this time should be sufficiently detailed to distinguish among alternatives. In addition, one should ensure that the alternatives are being compared on an equivalent basis (i.e., definitions of treatment alternatives are approximately at the same level of detail to allow preparation of comparable cost estimates).

Initially, specific technologies or process options were evaluated primarily on whether or not they could meet a particular remedial action objective. During alternative screening, the entire alternative is evaluated as to its effectiveness, implementability, and cost.

During the detailed analysis, the alternatives are evaluated against nine specific criteria and their individual factors rather than the general criteria used in screening. Therefore, individuals conducting the FS should be familiar with the nine criteria at the time of screening to better understand the direction that the analysis will be taking.

It is also important to note that comparisons during screening are usually made between similar alternatives (the most promising of which is carried forward for further analysis); whereas, comparisons during the detailed analysis will differentiate across the entire range of alternatives. The criteria used for screening are described in the following sections.

5.2.2.1 Effectiveness Evaluation

A key aspect of the screening evaluation is the effectiveness of each alternative in protecting human health and the environment. Each alternative should be evaluated as to the protectiveness it will provide and the reductions in toxicity, mobility, or volume it will achieve. Both short- and long-term components of protectiveness should be evaluated; short-term referring to the construction and implementation period, and long-term referring to the period after the remedial action is complete. Reduction of toxicity, mobility, or volume refers to changes in one or more characteristics of the hazardous substances or contaminated media by the use of treatment that decreases the threats or risks associated with the hazardous material.

5.2.2.2 Implementability Evaluation

Implementability, as a measure of both the technical and administrative feasibility of constructing, operating, and maintaining a remedial action alternative, is used during screening to evaluate the combinations of process options with respect to conditions at a specific site. Technical feasibility refers to the ability to construct, reliably operate, and meet technology-specific regulations for process options until a remedial action is complete; it also includes operation, maintenance, replacement, and monitoring of technical components of an alternative, if required, into the future after the remedial action is complete. Administrative feasibility refers to the ability to obtain approvals from other offices and agencies, the availability of treatment, storage, and disposal services and capacity, and the requirements for, and availability of, specific equipment and technical specialists.

Determinations of an alternative not being technically feasible and not being available will often preclude it from further consideration unless steps can be taken to change the conditions responsible for the determination. Often, this type of fatal flaw would have been identified during technology screening, and the infeasible alternative would not have been assembled. Negative factors affecting administrative feasibility will normally involve coordination steps to lessen the negative aspects of the alternative but will not necessarily eliminate an alternative from consideration.

5.2.2.3 Cost Evaluation

Typically, alternatives will have been defined well enough before screening that some estimates of cost are available for comparisons among alternatives. However, because uncertainties associated with the definition of alternatives often remain, it may not be practicable to define the costs of alternatives with the desirable accuracy (i.e., +50 percent to -30 percent) used in the detailed analysis.

Absolute accuracy of cost estimates during screening is not critical. The focus should be to make comparative estimates for alternatives with relative accuracy so that cost decisions among alternatives will be sustained as the accuracy of cost estimates improves beyond the screening process. The procedures used to develop cost estimates for alternative screening are similar to those used for the detailed analysis; the only differences would be in the degree of alternative refinement and in the sources used to develop cost components.

Cost estimates for screening alternatives typically will be based on a variety of cost-estimating data. Bases for screening cost estimates may include cost curves, generic unit costs, vendor information, conventional cost-estimating guides, and prior similar estimates as modified by site-specific information.

Prior estimates, site-cost experience, and good engineering judgments are needed to identify those unique items in each alternative that will control these comparative estimates. Cost estimates for items common to all alternatives or indirect costs (engineering, financial, supervision, outside contractor support, contingencies) do not normally warrant substantial effort during the alternatives screening phase.

Both capital and O&M costs should be considered, where appropriate, during the screening of alternatives. The evaluation should include those O&M costs that will be incurred for as long as necessary, even after the initial remedial action is complete. Likewise, potential future remedial action costs should be considered during alternative screening to the extent they can be defined. Present worth analyses should be used during alternative screening to evaluate expenditures that occur over different time periods. By discounting all costs to a common base year, the costs for different remedial action alternatives can be compared on the basis of a single figure for each alternative.

A more detailed discussion of evaluating cost is presented in Chapter 7.

5.2.2.4 Innovative Technologies

Technologies are classified as innovative if they are developed fully but lack sufficient cost or performance data for routine use at Superfund sites. In many cases, it will not be possible to evaluate alternatives incorporating innovative technologies on the same basis as available technologies, because insufficient data exist on innovative technologies. If treatability testing is being considered to better evaluate an innovative technology, the decision to conduct a test should be made as early in the process as possible to avoid delays in the RI/FS schedule.

Innovative technologies would normally be carried through the screening phase if there is a reason to believe that the innovative technology will be shown to offer significant advantages. These advantages may be in the form of better treatment performance or implementability, fewer or lesser adverse impacts than other available approaches, or lower costs for similar levels of performance. A "reasonable belief" exists if all indications from other full-scale applications under similar circumstances or from bench-scale or pilot-scale treatability testing supports the expected advantages.

5.2.3 Alternative Screening

5.2.3.1 Criteria for Screening

Alternatives with the most favorable composite evaluation of all factors should be retained for further consideration during detailed analysis. Alternatives selected for further evaluation should, where practicable, preserve the range of treatment and containment technologies initially developed. It is not a requirement that the entire range of alternatives originally developed be preserved if all alternatives in a portion of the range are not good viable options.

The target number of alternatives to be carried through screening should be set on a site-specific basis in conjunction with the lead

agency. It is expected that the typical target number of alternatives carried through screening (including containment and no-action alternatives) would not exceed 10. Fewer alternatives should be carried through screening, if possible, while adequately preserving the range of remedies. If the alternatives being screened are still medium-specific, rather than addressing the entire site or operable unit, the number of alternatives retained for each specific medium would be considerably less than 10.

5.2.3.2 Selection of Alternatives for Detailed Analysis

Once the evaluation has been conducted for each of the alternatives, the lead agency and its contractor should meet with the support agency to discuss each of the alternatives being considered. This meeting does not correspond to a formal quality control review stage but provides the lead agency and its contractor with input from the support agency and serves as a forum for updating the support agency with the current direction of the FS.

The alternatives recommended for further consideration should be agreed upon at this meeting so that documentation of the results of alternative screening is complete; any additional investigations that may be necessary are identified; and the detailed analysis can commence.

Unselected alternatives may be reconsidered at a later step in the detailed analysis if similar retained alternatives continue to be evaluated favorably or if information is developed that identifies an additional advantage not previously apparent. This provides the flexibility to double check a decision that was made previously or to review variations of alternatives being considered (e.g., consideration of other similar process options). However, it is expected that under most circumstances, once an alternative is screened out, it will not be reconsidered for selection.

5.2.3.3 Post-screening Tasks

The completion of the screening process leads directly into the detailed analysis and may serve to identify additional investigations that may be needed to adequately evaluate alternatives. To ensure a smooth transition from the screening of alternatives to the detailed analysis, it will be necessary to identify and begin verifying action-specific ARARs and initiate treatability testing (if not done previously) and additional site characterization, as appropriate.

Although the consideration of action-specific ARARs begins earlier as process options are combined, the identification of action-specific ARARs will need to be more definitive as the alternatives become better defined. At the conclusion of screening, sufficient information should exist on the technologies and configurations of greatest interest so that the lead agency can initiate discussion with the support agency on action-specific ARARs. As with chemical-specific ARARs, action-specific ARARs should include all Federal requirements and any State requirements that either are more stringent than Federal ARARs or specify requirements where no Federal ARARs exist.

Once the field of alternatives has been narrowed, the technology processes of greatest interest can be identified. At this point, the need for treatability tests (if not identified earlier) can be determined for process options that will require additional data for detailed analysis. Although the results of treatability testing will not be used until the detailed analysis, they should be initiated as early in the process as possible to minimize any potential delays on the FS schedule. The type and scope of treatability tests depends on the expected data requirements for detailed analysis of alternatives. Factors involved in determining the need for and scope of treatability studies are discussed in Chapter 6.

In some cases, the need for additional site characterization may also be identified during the screening phase. Because the nature and extent of contamination should be well defined by the end of the RI site

characterizations, field investigations at this time should be conducted only to better define the effect of site conditions on the performance of the technology processes of greatest interest.

5.3 COMMUNITY RELATIONS DURING ALTERNATIVE SCREENING

Community relations activities implemented earlier in the RI/FS process may be appropriate for screening. Activities should focus on providing information to the community concerning the screening of alternatives and on obtaining feedback on community interests and concerns. These activities should be site- and community-specific and are usually stipulated in the community relations plan that is prepared during the scoping of the project. It is important to note that public interest typically increases as the feasibility study progresses; and that the technical adequacy of a remedy does not ensure community acceptance. Therefore, the community relations activities should be planned and conducted to address such interest and potential concerns.

Community relations activities that may be appropriate include, but are not limited to, briefings of local officials and concerned citizens on alternatives under consideration, a fact sheet or workshop presenting citizens with alternatives identified for detailed analysis, a small group meeting with citizens involved with the site, and news releases describing technologies being evaluated.

For some sites, it may be appropriate to combine some community relations activities for screening with those for alternative development, especially when these two FS phases are combined to streamline the process. Presentations to the community on the screening of technologies and the development and screening of alternatives may, at times, be grouped together logically to provide information on how alternatives were selected for detailed analysis.

In general, community relations activities during screening are most appropriate at sites where citizens are actively concerned over

site conditions and remedial actions being implemented at the site. The following are objectives of community relations activities during this phase:

- Keep the community apprised of the Agency's decisionmaking process
- Enhance citizen understanding of issues pertaining to the screening and selection of remedial alternatives
- Obtain feedback from the community on alternatives under consideration

The level of effort for community relations during this phase should be described in the community relations plan.

5.4 REPORTING AND COMMUNICATION DURING ALTERNATIVE SCREENING

Coordination between the lead and support agencies is important throughout the RI/FS process. During screening, the following key coordination points are required:

- The lead and support agencies should agree on the set of alternatives selected for detailed analysis.
- The lead and support agencies must coordinate identification of action-specific ARARs.
- The lead agency and its contractor are to evaluate the need for additional investigations that may be needed prior to conducting the detailed analysis.

Table 5-1 summarizes the communication requirements among the lead agency, the support agency, and the FS contractor during screening.

Table 5-1
REPORTING AND COMMUNICATION
DURING SCREENING

Information Needed	Purpose	Potential Methods of Information Provision
Results of Alternative Screening	For lead agency and contractor to communicate and reach agreement on alternative screening; for lead agency to obtain support agency review and comment	Meeting Tech Memo Other
Identification of Action-Specific ARARs	For lead agency to obtain input from the support agency on action-specific ARARs	Meeting Letter Other
Need for Additional Investigation	For lead agency and contractor to determine whether additional investigations are needed to evaluate selected alternatives; for lead agency to obtain support agency review and comment	Meeting Tech Memo Other

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Reporting approaches should be agreed upon between the FS contractor and the lead agency RPM. Although no formal report is required during alternative development and screening, some form of written documentation of the methods, rationale, and results of alternative screening (e.g., graphical representation similar to Figures 4-5 and 4-6 or a technical memorandum) needs to be provided to the lead and support agencies. If a technical memorandum is prepared, it can serve as the basis for later development of the chapter(s) in the FS report that discusses the development and screening of alternatives.

Because the final RI/FS report may eventually be subject to judicial review, the procedures for evaluating, defining, and screening alternatives should be well documented, showing the rationale for each step. The following types of information should be documented to the extent possible:

- Chemical- and/or risk-based remedial objectives associated with the alternative

- Modifications to any media-specific alternatives initially developed to ensure that risk from multiple-pathway exposures and interactions among source- and ground-water-remediation strategies are addressed

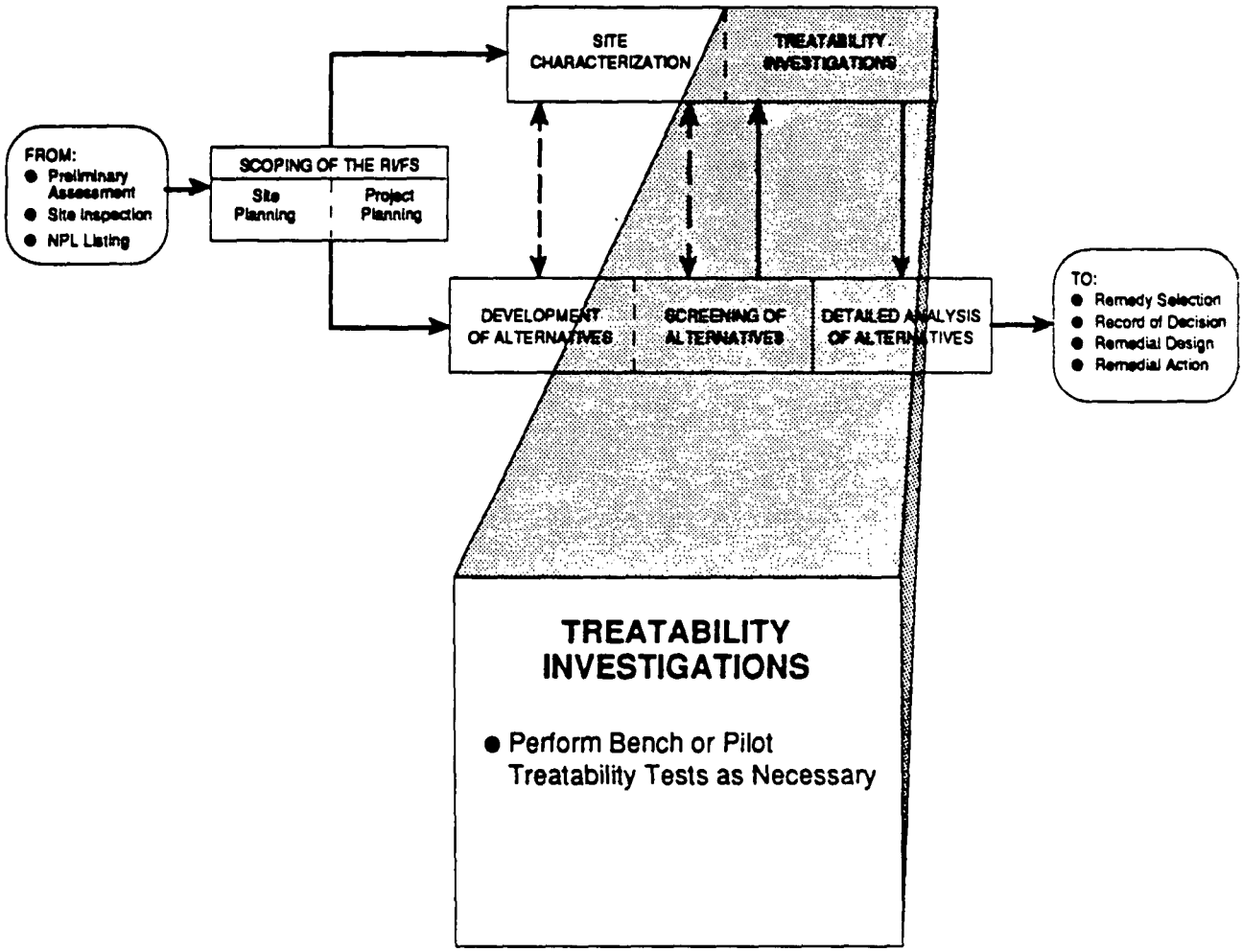
- Definition of each alternative including extent of remediation, volume of contaminated material, size of major technologies, process parameters, cleanup time frames, transportation distances, and special considerations

- Notation of process options that were not initially screened out and are being represented by the processes comprising the alternative

- Screening evaluation summaries of each alternative

- Comparison of screening evaluations among alternatives

CHAPTER 6
TREATABILITY INVESTIGATIONS



CHAPTER 6
TREATABILITY INVESTIGATIONS

6.1 INTRODUCTION

As discussed earlier, the phased RI/FS process is intended to better focus the site investigation so that only those data necessary to support the RI/FS and the decisionmaking process are collected. Data needs are initially identified on the basis of the understanding of the site at the time the RI/FS is initially scoped. Therefore, initial sampling and testing efforts may be limited until a more complete understanding of the site allows subsequent sampling efforts to be better focused. As site information is collected during the RI and alternatives are being developed, additional data needs necessary to adequately evaluate alternatives during the detailed analysis are often identified. These additional data needs may involve the collection of site characterization data, as described in Chapter 3, or treatability studies to better evaluate technology performance. This chapter is intended to provide an overview of the types of treatability studies (i.e., bench scale, pilot scale) that may be used, their specific purposes, and important factors that need to be considered when contemplating their use.

6.1.1 Objectives of Treatability Investigations

The primary objectives of treatability studies are:

- Provide sufficient data to allow treatment alternatives to be fully developed and evaluated during the detailed analysis and support remedial design of a selected alternative

- Reduce cost and performance uncertainties for treatment alternatives to acceptable levels so that a remedy can be selected

6.1.2 Overview of Treatability Investigations

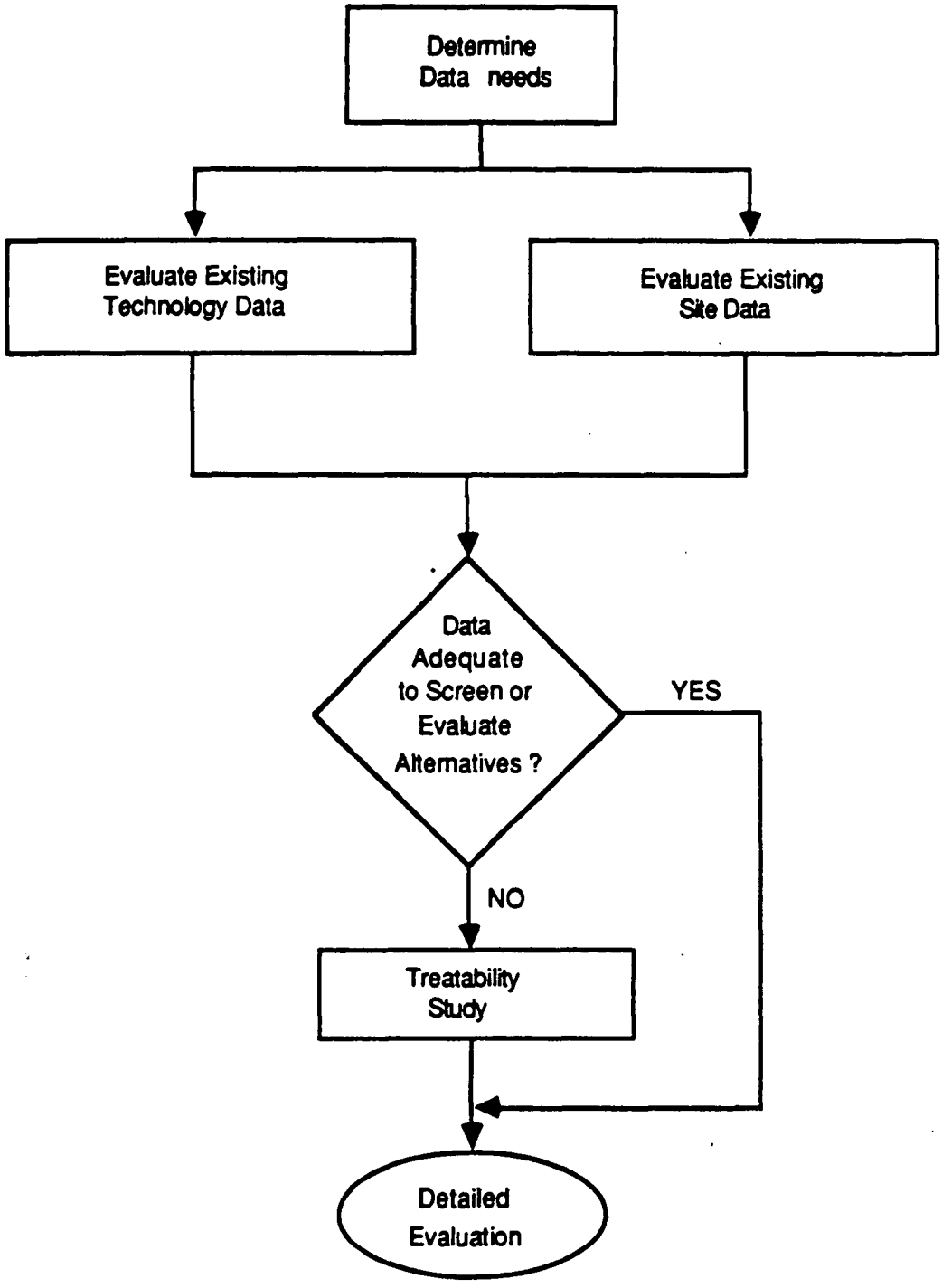
Treatability studies to collect data on technologies identified during the alternative development process are conducted, as appropriate, to provide additional information for evaluating technologies. The RI/FS contractor and the lead agency's RPM must review the existing site data and available information on technologies to determine if treatability investigations are needed. As discussed earlier, the need for treatability testing should be identified as early in the RI/FS process as possible. A decision to conduct treatability testing may be made during project scoping if information indicates such testing is desirable. However, the decision to conduct these activities must be made by weighing the cost and time required to complete the investigation against the potential value of the information in resolving uncertainties associated with selection of a remedial action. In some situations, the need for treatability investigations may not be identified until later in the process and, therefore, may be postponed until the remedial design phase.

The decision process for treatability investigations is shown conceptually in Figure 6-1 and consists of the following steps:

- Determining data needs
- Reviewing existing data on the site and available literature on technologies to determine if existing data are sufficient to evaluate alternatives
- Performing treatability tests, as appropriate, to determine performance, operating parameters, and relative costs of potential remedial technologies
- Evaluating the data to ensure that data quality objectives are met

FIGURE 6-1

TREATABILITY INVESTIGATIONS



6.2 DETERMINATION OF DATA REQUIREMENTS

To the extent possible, data required to assess the feasibility of technologies should be gathered during the site characterization (e.g., moisture and heat content data should be collected if incineration of an organic waste is being considered). Because data requirements will depend on the specific treatment process and the contaminants and matrices being considered, the results of the site characterization will influence the types of alternatives developed and screened, which will in turn influence additional data needs. However, data collected during site characterization will not always be adequate for assessing the feasibility of remedial technologies, and, in fact, the need for detailed data from treatability tests may not become apparent until the initial screening of alternatives has been completed. A description of data requirements for selected technologies is presented in Table 6-1. The Technology Screening Guide for Treatment of Contaminated Soils and Sludges (EPA, under preparation) summarizes data needs for a larger number of available and innovative technologies. The Superfund Innovative Technology Evaluation (SITE) program is another source to assist with the identification of data needs and to obtain performance information on innovative technologies.

Additional data needs can be identified by conducting a more exhaustive literature survey than was originally conducted when potential technologies were initially being identified. The objectives of a literature survey are as follows:

- Determine whether the performance of those technologies under consideration have been sufficiently documented on similar wastes considering the scale (e.g., bench, pilot, or full) and the number of times the technologies have been used

- Gather information on relative costs, applicability, removal efficiencies, O&M requirements, and implementability of the candidate technologies

TABLE 6-1. TYPICAL DATA REQUIREMENTS FOR REMEDIATION TECHNOLOGIES

Technology	Waste Matrix	Example Data Required
Thermal Destruction	Soils	Moisture content Heat value Chlorine content Destruction efficiency
	Liquids	Heat value Concentration of metals Destruction efficiency
Air Stripping	Ground Water	Concentration of volatile contaminants Concentration of non-volatile contaminants Contaminant removal efficiencies (obtainable from mathematical models)
Metal Hydroxide Precipitation	Ground Water	Metals concentration Contaminant removal efficiency Sludge generation rate and composition
In Situ Vapor Extraction	Soils	Soil type Particle size distribution Concentration of volatile compounds Presence of non-volatile contaminants Contaminant removal efficiencies (usually requires bench- or pilot-scale work)

[Note: Tables used in this outline are only partial examples.]

- Determine testing requirements for bench or pilot studies, if required

6.3 TREATABILITY TESTING

Certain technologies have been sufficiently demonstrated so that site-specific information collected during the site characterization is adequate to evaluate and cost those technologies without conducting treatability testing. For example, a ground-water investigation usually provides sufficient information from which to size a packed tower air stripper and prepare a comparative cost estimate. Other examples of when treatability testing may not be necessary include:

- A developed technology is well proven on similar applications.

- Substantial experience exists with a technology treating well documented waste materials. (For example, air stripping or carbon adsorption of ground water contain organic compounds that have been treated previously in other applications.)

- Relatively low removal efficiencies are required (e.g., 50 to 90 percent), and data are already available.

Frequently, technologies have not been sufficiently demonstrated or characterization of the waste alone is insufficient to predict treatment performance or to estimate the size and cost of appropriate treatment units. Furthermore, some treatment processes are not sufficiently understood for performance to be predicted, even with a complete characterization of the wastes. For example, it is often difficult to predict biological toxicity in a biological treatment plant without pilot tests. When treatment performance is difficult to predict, an actual testing of the process may be the only means of obtaining the necessary data. In fact, in some situations it may be more cost-effective to test a process on the actual waste than it would be to characterize the waste in sufficient detail to predict performance.

Treatability testing performed during an RI/FS is used to adequately evaluate a specific technology, including evaluating performance, determining process sizing, and estimating costs in sufficient detail to support the remedy-selection process. Treatability testing in the RI/FS is not meant to be used soley to develop detailed design or operating parameters that are more appropriately developed during the remedial design phase.

Treatability testing can be performed by using bench-scale or pilot-scale techniques, which are described in detail in the following sections. However, in general, treatability studies will include the following steps:

- Preparing a work plan (or modifying the existing work plan) for the bench or pilot studies
- Performing field sampling, and/or bench testing, and/or pilot testing
- Evaluating data from field studies, and/or bench testing, and/or pilot testing
- Preparing a brief report documenting the results of the testing

6.3.1 Bench-Scale Treatability Studies

Bench testing usually is performed in a laboratory, in which comparatively small volumes of waste are tested for the individual parameters of a treatment technology. These tests are generally used to determine if the "chemistry" of the process works and are usually performed in batch (e.g., "jar tests"), with treatment parameters varied one at a time. Because small volumes and inexpensive reactors (e.g., bottles or beakers) are used, bench tests can be used economically to test a relatively large number of both performance and waste-composition variables. It is also possible to evaluate a treatment system made up of several technologies and to generate limited amounts of residuals for evaluation. Bench tests are typically performed for projects involving treatment or destruction technologies. How-

ever, care must be taken in attempting to predict the performance of full-scale processes on the basis of these tests.

Bench-scale testing is useful for a developing technology, because it can be used to test for a wide variety of operating conditions.[1] In such cases, bench tests can also be used to determine broad operating conditions to allow optimization during additional bench or possibly larger-scale pilot tests to follow.

Bench-scale testing usually consists of a series of tests, with the results of the previous analysis determining the next set of conditions to evaluate. The first tests usually cover a broad range of potential operating conditions in order to narrow the conditions for subsequent tests. For example, pH is the most important parameter for hydroxide precipitation of heavy metals. An initial "screening" jar test might be performed in which the pH range is varied from 7 through 12 in whole pH units. After finding a minimum metals concentration at pH 9, additional testing could be performed at narrower pH intervals around 9. The initial screening tests need not be performed to the same high level of accuracy used in the final tests to predict treatment effectiveness.

Bench testing can usually be performed over a few weeks or months, and the costs are usually only a small portion of the total RI/FS cost. Costs for bench testing are usually significantly lower than those for pilot testing for similar technologies.

Bench-scale testing should be performed, as appropriate, to determine the following:

- Effectiveness of the treatment alternative on the waste (note that for some technologies bench-scale testing may not be sufficient to make a final effectiveness determination)

[1] Bench tests may also be conducted for well-developed and documented technologies that are being applied to a new waste.

- Differences in performance between competing manufacturers (e.g., activated carbon adsorption isotherms, polymer jar tests)

- Differences in performance between alternative chemicals (e.g., alum versus lime versus ferric chloride versus sodium sulfide)

- Sizing requirements for pilot-scale studies (e.g., chemical feed systems)

- Screening of technologies to be pilot tested (e.g., sludge dewatering)

- Sizing of those treatment units that would affect the cost of the technology sufficiently to affect the FS evaluation process

- Compatibility of materials with the waste

6.3.1.1 Preplanning Information Needs

The preplanning information needed to prepare for a bench-scale treatability test includes preparing and identifying test procedures; a waste sampling plan; waste characterization; treatment goals (e.g., how clean or resistant to leaching does the waste need to be); data requirements for estimating the cost of the technology being evaluated (e.g., sufficient for an order of magnitude cost estimate (i.e., +50/-30 percent)); and test services, equipment, chemical, and analytical service procurement.

6.3.2 Pilot-Scale Treatability Studies

Pilot studies are intended to simulate the physical as well as chemical parameters of a full-scale process, and therefore the treatment unit sizes and the volume of waste to be processed in pilot systems greatly increase over those of bench scale. As such, pilot units are intended to bridge the gap between bench and full-scale and are intended to more accurately simulate the operation of the full-scale process than would bench-scale testing.

Pilot units are designed as small as possible to minimize costs, yet large enough to get the data required for scaling up. Pilot units are usually sized to minimize the physical and geometric effects of test equipment on treatment performance to simulate full-scale performance. Examples of these effects include mixing, wall effects, accurate settling data, and generation of sufficient residues (sludges, off gases, etc.) for additional testing (dewatering, fixation, etc.). Pilot units are operated in a manner as similar as possible to the manner of operation of the full-scale system (i.e., if the full-scale system will be operated continuously, then the pilot system would usually be operated continuously).

In many instances, significant time is required to make a changeover in operating conditions of a pilot plant and get a reliable result of the change. Therefore, time and budget constraints often limit the ability to test a large number of operating conditions. Since pilot tests usually require large volumes of waste that may vary in characteristics, consideration should be given to performing tests on wastes that are representative of actual site conditions and full-scale operations (e.g., it may be necessary to blend or spike wastes to test all waste characteristics anticipated at the site and/or to conduct onsite tests using mobile laboratories).

6.3.2.1 Preplanning Information Needs

In addition to the preplanning requirements for bench-scale tests, information needed to prepare for a pilot-scale treatability test includes:

- Site information that would affect pilot-test requirements (i.e., waste characteristics, power availability, etc.)
- Waste requirements for testing (i.e., volumes, pretreatment, etc.)
- Data requirements for technologies to be tested

Because substantial quantities of material may be processed in a pilot test and because of the material's hazardous characteristics, special pre-

cautions may be required in handling transport and disposal of processed waste. It may be necessary to obtain an agreement with a local sewer authority or cognizant State agencies or to obtain an NPDES permit for off-site discharge of treated effluent. Solid residuals must be disposed of properly offsite or stored onsite to be addressed as part of the remedial action.

6.4 BENCH VERSUS PILOT TESTING

Alternatives involving treatment or destruction technologies may require some form of treatability testing, if their use represents first-of-its-kind applications on unique or heterogeneous wastes.

Once a decision is made to perform treatability studies, the RI/FS contractor and lead agency remedial project manager will have to decide on the type of treatability testing to use. This decision must always be made taking into account the technologies under consideration, performance goals, and site characteristics.

The choice of bench versus pilot testing is affected by the level of development of the technology. For a technology that is well developed and tested, bench studies are often sufficient to evaluate performance on new wastes. For innovative technologies, however, pilot tests may be required since information necessary to conduct full-scale tests is either limited or nonexistent.

Pilot studies are usually not required for well-developed technologies, except when treating a new waste type or matrix that could affect the physical operating characteristics of a treatment unit. For example, incineration of fine sands or clay soils in a rotary kiln that has been developed for coarser solids can result in carryover of fine sands into the secondary combustion chamber.

During the RI/FS process, pilot-scale studies should be limited to situations in which bench-scale testing or field sampling of physical or chemical parameters provide insufficient information from which to evaluate an

alternative (e.g., it is difficult to evaluate the ability of a rotary kiln incinerator to handle a new waste matrix using a bench-scale test). Pilot-scale tests may also be required when there is a need to investigate secondary effects of the process, such as air emissions, or when treatment residues (sludge, air emissions) are required to test secondary treatment processes.

Because of the time required to design, fabricate, and install pilot-scale equipment and to perform tests for a reasonable number of operating conditions, conducting a pilot study can add significant time to the RI/FS schedule and can be quite costly. The decision to perform a pilot test should, therefore, be considered carefully and made as early in the process as possible to minimize potential delays of the FS.

To determine the need for pilot testing, the potential for improved performance or savings in time or money during the implementation of a technology should be balanced against the additional time and cost for pilot testing during the RI/FS. Technologies requiring pilot testing should also be compared to technologies that can be implemented without pilot testing. Innovative technologies should be considered if they offer the potential for more permanent treatment, destruction of the waste, or significant savings in time or money required to complete a remedial action.

The final decision as to how much treatability testing (or collection of additional data of any kind) should be undertaken must balance the value of the additional data against increased cost, schedule delay, and level of allowable uncertainty in the remedy-selection process. Generally, one of the following choices must be made:

- Collect more data using treatability testing
- Provide additional safety factors in the remedial design to accommodate some uncertainties
- Proceed with the remedy selection, accepting the uncertainty and the potential cost and performance consequences

The final decision may also be a combination of several of these choices. The lead agency's RPM must base the decision upon the characteristics of the site, the cost of the studies, and the uncertainties of proceeding without them.

Table 6-2 provides a comparison between bench and pilot studies, and Table 6-3 shows examples of bench and pilot testing programs.

6.4.1 Testing Considerations

Shipment of substantial volumes of contaminated material from a site for testing can prove to be difficult; residual material not consumed in testing will need to be disposed of safely, and the disposal must be adequately documented. Therefore, the volume of materials to be tested offsite should be minimized to avoid related problems.

A second testing consideration is the possible difficulty of getting a representative sample of waste for treatability testing. For example, although ground-water samples collected from monitoring wells during site characterization may be available for testing treatment technologies, separate extraction wells may need to be used to produce the required ground-water flow patterns during remedial actions. Consequently, because the characteristics of ground water from extraction wells may be different from monitoring wells, representative waste samples may be unavailable until extraction wells are installed and pumped. Samples sufficient for bench testing can be collected from monitoring wells, if allowances are made for potential differences in the composition of wastes to be derived from extraction wells. While pilot testing may require volumes of waste greater than can be collected from monitoring wells--unless monitoring wells are sized sufficiently--pilot tests can be performed on water produced from extraction wells during pump testing and before the remedial action begins. A similar concern arises when trying to obtain representative samples for testing the treatment of contaminated soil. Since the soil characteristics will vary both horizontally and vertically on the site it may not be possible to obtain a sample that fully represents full-scale conditions without blending or spiking.

TABLE.6-2. BENCH AND PILOT STUDY PARAMETERS

Parameter	Bench	Pilot
Purpose	Define process kinetics, material compatibility, impact of environmental factors, types of doses of chemicals, active mechanisms, etc.	Define design and operation criteria, materials of construction, ease of material handling and construction, etc.
Size	Laboratory or bench top	1-100% of full scale
Quantity of Waste and Materials Required	Small to moderate amounts	Relatively large amounts
Number of Variables That Can Be Considered	Many	Few
Time Requirements	Days to weeks	Weeks to months
Typical Cost Range	0.5-2% of capital costs of remedial action	2-5% of capital costs of remedial action
Most Frequent Location	Laboratory	Onsite
Limiting Considerations	Wall, boundary and mixing effects; volume effects; solids processing difficult to simulate, transportation of sufficient waste volume	Limited number of variables; large waste volume required; safety, health, and other risks; disposal of process waste material

TABLE 6-3. EXAMPLES OF BENCH- AND PILOT-SCALE TESTING PROGRAMS

Remedial Technology	Example Testing Programs
A. Air Pollution and Gas Migration Control 1. Capping 2. Dust Control 3. Vapor Collection and Treatment (carbon adsorption, air stripping, etc.)	Bench: Soil density and bearing capacity vs. moisture content curves for proposed capping materials Pilot: In-place soil densities; determination of gas withdrawal rates to control releases
B. Surface Water Controls 1. Capping 2. Grading 3. Revegetation 4. Diversion and Collection	Bench: Column testing of capping material compatibility with wastes present Pilot: In-place testing of geotextiles for control of erosion in grassed diversion ditches
C. Leachate and Ground-Water Controls 1. Containment barriers (slurry walls, grout curtains, etc.) 2. Ground-water pumping (well points, suction wells, etc.) 3. Subsurface collection drains 4. Permeable treatment beds (limestone, activated carbon) 5. Capping	Bench: Determination of basicity and headloss vs. grain size of limestone materials for a treatment bed; determination of chemical compatibility of a compacted clay with a leachate stream Pilot: In-place testing of a soil-type and grain-size specification and tile-drain configuration for a subsurface collection drain
D. Direct Waste Control 1. Thermal Treatment 2. Solidification/Stabilization 3. Biological Treatment o Activated sludge o Facultative lagoons o Trickling filters 4. Chemical Treatment o Oxidation/reduction o Precipitation o Neutralization o Ion exchange resins 5. Physical Treatment o Carbon adsorption o Flocculation o Sedimentation	Bench: Characterization of chemical and heat content of hazardous waste mixes; chemical, physical, and biological treatability studies to define rate constants, minimal-maximal loading rates and retention times, optimal pH and temperature, sludge generation rates and characteristics, and oxygen transfer characteristics; chemical type and dose rates; solids flux rate vs. solids concentration in sludge thickening systems; air/volume ratios for stripping towers

Table 6-3
(Continued)

Remedial Technology	Example Testing Programs
o Membrane processes o Dissolved air flotation o Air stripping o Wet air oxidation	Pilot: Test burns to determine retention time, combustion-chamber and after-burner temperatures, destruction and removal efficiency, and fuel requirements for the incineration of a waste; endurance performance tests on membranes in reverse-osmosis units for ground-water treatment; in situ microbial-degradation testing of nutrient-dose and aeration rates to support in-place degradation of underground leak; evaluation of in-place mixing procedures for the solidification of a sludge in a lagoon
6. In Situ Treatment o Vapor Extraction o Soil flushing o Microbial degradation o Neutralization/ detoxification o Precipitation o Nitrification	
7. Land Disposal (landfill, land application)	
E. Soil and Sediment Containment and Removal 1. Excavation 2. Dredging 3. Grading 4. Capping 5. Revegetation	Bench: Determination of soil-adsorptive (cation exchange capacity) properties and chemical composition Pilot: Small-scale dredging to assess sediment resuspension or production rates

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6.4.2 Data-Quality Objectives

The data quality required for analytical results of treatability tests is a key concern since it greatly affects the cost and time required for the analyses. Analytical levels and corresponding levels of quality are discussed in Chapter 2 of this guidance (Figure 2-3).

Since the results of bench and pilot studies are used to support selection of a remedial alternative, results of such studies will support the ROD and become part of the Administrative Record. Furthermore, results of treatability testing may also be used on other sites with similar characteristics. Therefore, procedures followed in testing will need to be well documented. Sampling and analyses for tests used to develop predictive results will need to be performed with the same level of accuracy and care that was used during the site characterization. Because cost and time required for analyses increase significantly with increased quality, potential savings can be derived by carefully determining the level of data quality required for the analytical level to be used.

Table 6-4 presents the data quality usually required for the various analyses that may be performed during treatability investigations. Bench- and pilot-scale testing require some moderate and some high-quality data. Sufficient high-quality data are needed to document treatment performance of the technologies considered for further evaluation as well as those dropped from consideration.

6.5 TREATABILITY TEST WORK PLAN

Laboratory testing can be expensive and time consuming. A well-written work plan is a necessary document if a treatability testing program is to be completed on time, within budget, and with accurate results. Preparation of a work plan provides an opportunity to mentally run the test and review comments prior to starting the test. It also reduces the ambiguity of communication between the lead agency's RPM, the contractor's project manager, the technician performing the test, and the laboratory technician performing the analyses on test samples. The work plan, which may be an amendment to the

TABLE 6-4. DATA QUALITY FOR TREATABILITY INVESTIGATIONS

Analytical Level	Field Data	Bench/Pilot Data
Level II/ Level III	Feasibility screening	Testing to optimize operating conditions Monitoring Predesign sizing
Level IV/ Level V	Enforcement related evaluations and recommendations of alternatives	Establish design criteria establishing standards documenting performance in treatability studies to screen alternatives

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original work plan, if the need for the treatability tests was not identified until later in the process, or a separate one specifically for this phase. Regardless, the work plan should be reviewed and approved by the lead agency's RPM. The RPM and RI/FS contractor should determine the appropriate level of detail for the work plan since a detailed plan is not always needed and will require time to prepare and approve. In some situations the original work plan may adequately describe the treatability tests and a separate plan is not required (e.g., the need for treatability testing can be identified during the scoping phase if existing information is sufficient). Section 2.4 and Appendix B-2 provide additional information on work plan preparation.

6.5.1 Bench-Scale Treatability Work Plan

Table 6-5 provides a suggested work plan format for bench-scale testing; the various sections of the recommended format for the work plan are described below.

- Project Description and Site Background--Briefly describe the site and the types, concentrations, and distributions of contaminants of concern (concentrating on those for which the technology is being considered).

- Remedial Technology Description--Give a brief description of the technology(ies) to be tested.

- Test Objectives--Describe the purpose of the test, the data that are to be collected from the bench test, and how the data will be used to evaluate the technology.

- Specialized Equipment and Materials--Describe unique equipment or reagents required for the test.

- Experimental Procedures--List specific steps to be performed in carrying out the bench test; include volumes to be tested, descriptions of reactors to be employed, and materials needed (i.e.,

TABLE 6-5. SUGGESTED FORMAT FOR BENCH-SCALE WORK PLAN

1. Project Description and Site Background
2. Remediation Technology Description
3. Test Objectives
4. Specialized Equipment and Materials
5. Laboratory Test Procedures
6. Treatability Test Plan Matrix and Parameters to Measure
7. Analytical Methods
8. Data Management
9. Data Analysis and Interpretation
10. Health and Safety
11. Residuals Management

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transfer by graduated cylinder 500 ml of waste to a 600 ml borosilicate glass beaker). Specify the accuracy of measurements by specifying standard laboratory glassware (i.e., a graduated cylinder has 5 percent accuracy but a pipet is 1 percent); describe steps sequentially; and describe how samples are to be taken for analysis, which containers are to be used, which preservatives, etc.

- Treatability Test Plan--Include the variable conditions that are to be tested (e.g., a combination of 4 pH units and 5 doses of a chemical would produce 40 discrete tests [if replicated]); include parameters to be measured if they vary for different test conditions.

- Analytical Methods--The analytical method is dependent on test objectives, technology, waste, and other site factors. Survey available analytical methods and select the most appropriate. Describe analytical procedures or cite and reference standard procedures to be employed; define the level of accuracy needed for each of the analyses; perform initial testing to roughly determine optimal operating conditions; and use moderately accurate analytical techniques or analyses of only one or a few indicator compound(s) to greatly reduce the time and cost of these initial tests. After achieving best treatment, perform more complete and accurate testing to confirm the earlier results. Most bench tests require results in short order to allow varied test runs. Bench tests remote from the analyzing laboratory are difficult; therefore, analyze the duplicate final or check samples by the CLP, if necessary.

- Data Management--Testing procedures must be well documented, using bound notebooks, photographs, etc.; provisions need to be made for making backup copies of critical items of data. Describe the parameters to be measured, accuracy that the results are to be recorded to, and how these are to be recorded. Prepare a sample data sheet to be used in the bench test; include procedures to be employed to ensure that the results are protected from loss.

- Data Analysis and Interpretation--Describe in detail the procedures to be followed to reduce raw analytical data to a form useful for interpretation. The most helpful are methods of graphical interpretation based on known physical or chemical phenomena, or common practice (e.g., plotting concentrations of metal remaining in solution versus pH or chemical dosage).

- Health and Safety--Modify the site health and safety plan as needed to account for waste handling and onsite testing operations.

- Residual Management--Describe the types of residuals anticipated and how they will be disposed of.

6.5.2 Pilot Scale Treatability Work Plan

Table 6-6 contains a suggested work plan format. Although many of the sections are similar to those of the bench-scale work plan format, differences between the two are discussed below.

- Pilot Plant Installation and Startup--For onsite pilot studies, describe the equipment required and method to be employed to get the equipment onsite and installed for the test period.

- Pilot Plant Operation and Maintenance Procedures--Describe the specific conditions under which the pilot test will be conducted. Pilot plants are normally run with relatively large volumes of waste to simulate full-scale operation and, therefore, usually have to provide that waste characteristics are measured and operating controls are adjusted (i.e., chemical feed rates) to match instructions for startup and shutdown of the pilot plant; this needs to be included in the procedures list.

- Parameters to be Tested--List the operating conditions under which the pilot units are to be tested and the variations in control

TABLE 6-6. SUGGESTED FORMAT FOR PILOT-SCALE WORK PLAN

1. Project Description and Site Background
2. Remedial Technology Description
3. Test Objectives
4. Pilot Plant Installation and Startup
5. Pilot Plant Operation and Maintenance Procedures
6. Parameters to be Tested
7. Sampling Plan
8. Analytical Methods
9. Data Management
10. Data Analysis and Interpretation
11. Health and Safety
12. Residuals Management

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parameters are to be evaluated (e.g., chemical feed rates or pH set points in a chemical precipitation test, or combustion temperature or gas residence time for an incinerator test).

- Sampling Plan--Describe locations and a schedule for samples to be taken from the pilot plant to determine performance; readings from in-line instruments, such as pH probes and sampling methods, containers, preservative, labeling, etc., should be included.

- Health and Safety Plan--Health and safety concerns are more critical during pilot tests because larger amounts of waste are involved and equipment is more complex. Equipment design and construction must comply with applicable code requirements.

6.6 APPLICATION OF RESULTS

6.6.1 Data Analysis and Interpretation

Following the completion of the treatability testing, results are reduced to a useful form according to the work plan. Data are interpreted on the technology's effectiveness, implementability, or cost, and anticipated results are compared with actual results. Graphical techniques are frequently used to present the results. Note that the level of reliability of the test results is usually based on the accuracy of the analytical methods employed.

Major differences between the anticipated and actual results may necessitate a modification of the work plan and retesting of the technology. In addition, raw-waste and effluent characteristics as well as by-products and emissions are evaluated to predict the ability of a full-scale unit to respond to variations in waste composition and meet performance requirements.

6.6.2 Use of the Results in the RI/FS Process

The purpose of the treatability evaluation is to provide information needed for the detailed analysis of alternatives and to allow selection of a

remedial action to be made with a reasonable certainty of achieving the response objectives. All results are useful, even negative ones, because they can be used to eliminate technologies for further consideration. The results of bench and pilot tests can be used to ensure that conventional and innovative treatment or destruction technologies can be evaluated equally with non-treatment alternatives during the detailed analysis phase of the FS. Secondary use of treatability results provides information for the subsequent detailed design of the selected remedial technology. Operating conditions must be carefully and completely documented so that this useful information can be used in the full-scale system.

The characteristics of residuals from the remedial technology should be determined during pilot testing. This information is useful in determining how the residuals can be handled or disposed and in predicting the effects of their disposal or emission. Information can often be collected to determine if the residuals should be considered hazardous wastes or disposed of as a non-hazardous waste.

6.6.3 Scaling up to Full-Scale Testing

The study findings need to be evaluated for application of the technology at full-scale; the limitations of the bench or pilot scale of the test (size, wall, and boundary effects, etc.) need to be compensated for. Scale-up can be done on the basis of either previous experience with the treatment equipment with other wastes or established rules of similitude (used to relate physical laws to variations in scale) and mathematical models. This evaluation should include a sensitivity analysis to identify the key parameters and unknowns that can affect a full-scale system. In the case of innovative technologies, full-scale systems may not be in wide use. The potential need for process modifications during design or operation must be considered.

6.7 COMMUNITY RELATIONS DURING TREATABILITY INVESTIGATIONS

Treatability testing is potentially controversial within a community and, therefore, additional community relations activities may be required.

An assessment of issues and concerns the community may have about planned treatability testing should be conducted. The assessment should augment the previously prepared community relations plan (if treatability testing were not part of the original work plan) and should include a discussion of any issues unique to the proposed testing such as onsite pilot testing, transporting contaminated materials offsite, schedule changes resulting from conducting bench or pilot tests, disposal of residuals, uncertainties pertaining to innovative technologies, and the degree of development of the technology being tested.

Additional community relations implementation activities may be recommended in the assessment and may include a public meeting to explain the proposed bench or pilot test, a fact sheet describing the technology and proposed test, a briefing to public officials about the treatability studies, and small group consultations with members of the community concerned about EPA's actions at the site. Other community relations activities may be needed, and consultations between the lead agency's project manager and the community relations coordinator should be used to establish the appropriate community relations activities.

6.8 REPORTING AND COMMUNICATION DURING TREATABILITY INVESTIGATIONS

Deliverables for the treatability investigations are listed in Table 6-7 and include the following:

- Revised work plans, as necessary, including bench and/or pilot tests
- Revised QAPP/FSP, as necessary
- Test results and evaluation report

The treatability test evaluation report should describe the testing that was performed, the results of the tests, and an interpretation of how the results would affect the evaluation of the remedial alternatives being considered for the site. Effectiveness of the treatment technology for the

TABLE 6-7. REPORTING AND COMMUNICATION DURING TREATABILITY INVESTIGATIONS

Information Needed	Purpose	Potential Method for Information Provision
Need for Treatability Testing	For lead agency and contractor to determine whether more cost and performance data are needed to evaluate alternatives and select remedy; for lead agency to obtain support agency review and comment	Meeting Tech Memo
Approval of Site Data Collection or Treatability Testing	Obtain lead agency approval of treatability activities	QAPP (revised) FSP Treatability Study Work Plan

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wastes on the site should be presented. This report should also contain an evaluation of how the test results would affect treatment costs developed during the detailed analysis of alternatives (e.g., chemical requirements or settling rates required for effective treatment). The report may often be used by other EPA and contractor staff to provide information for use on sites with similar characteristics.

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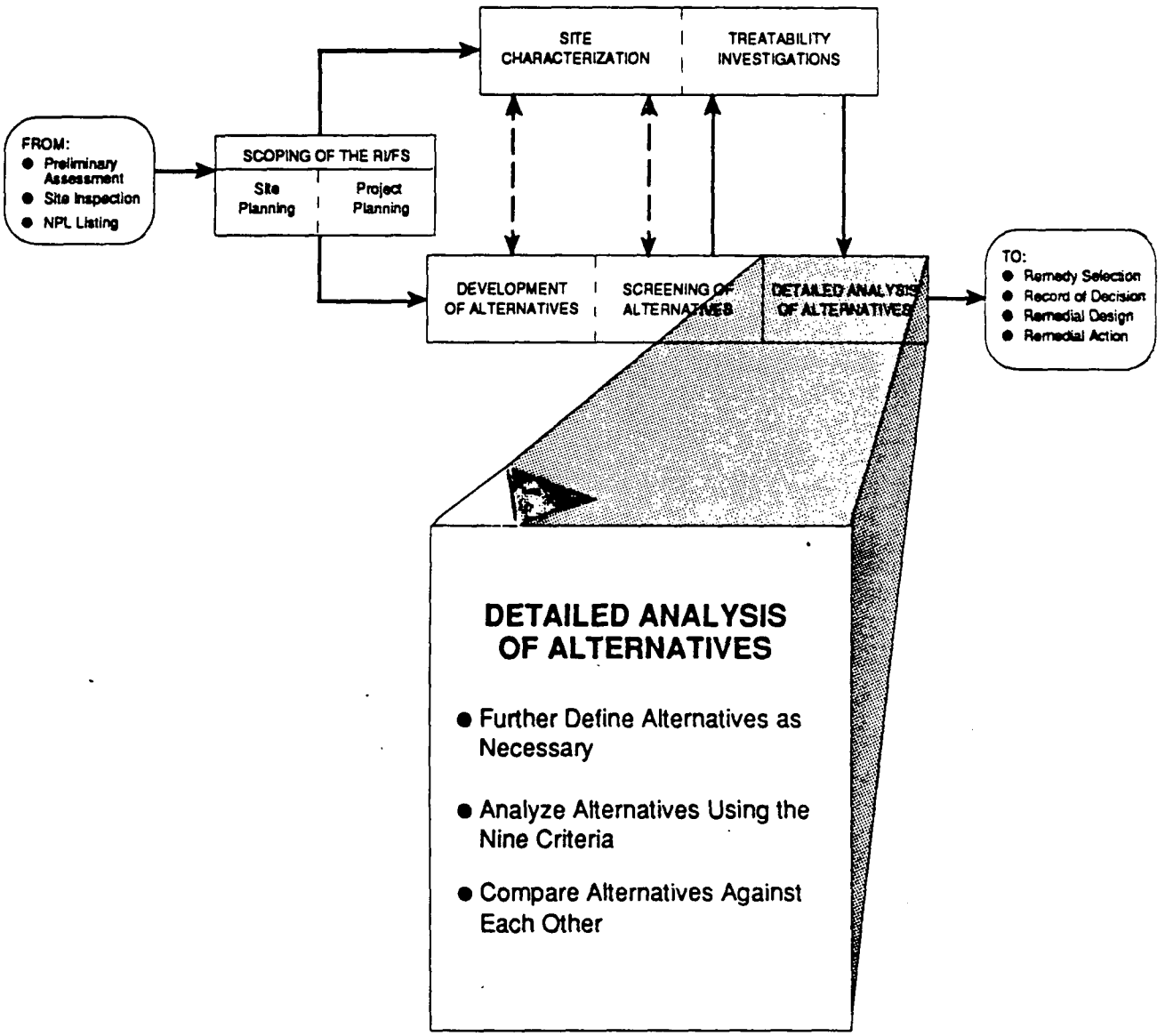
CHAPTER 7
DETAILED ANALYSIS OF ALTERNATIVES



CHAPTER 7
DETAILED ANALYSIS OF ALTERNATIVES

7.1 INTRODUCTION

7.1.1 Purpose of the Detailed Analysis of Alternatives

The detailed analysis of alternatives is the analyses and presentation of the relevant information needed to allow decisionmakers to select a site remedy, not the decisionmaking process itself. During the detailed analysis, each alternative is assessed against the nine evaluation criteria described in this chapter. The results of this assessment are arrayed such that comparisons can be made among alternatives and the key tradeoffs among alternatives can be identified. This approach to analyzing alternatives is designed to provide decisionmakers with sufficient information to adequately compare the alternatives, select an appropriate remedy for a site, and demonstrate satisfaction of the statutory requirements in the ROD.

The specific CERCLA requirements that must be addressed in the ROD and supported by the FS report are listed below:

- Be protective of human health and the environment
- Attain ARARs (or provide grounds for invoking a waiver)
- Be cost-effective
- Use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable

- o Satisfy the preference for treatment that reduces toxicity, mobility, or volume as a principal element (or provide an explanation in the ROD as to why it does not)

In addition, CERCLA places an emphasis on evaluating long-term effectiveness and related considerations for each of the alternative remedial actions. These statutory considerations include:

A) the long-term uncertainties associated with land disposal;

B) the goals, objectives, and requirements of the Solid Waste Disposal Act;

C) the persistence, toxicity, and mobility of hazardous substances and their constituents, and their propensity to bioaccumulate;

D) short- and long-term potential for adverse health effects from human exposure;

E) long-term maintenance costs;

F) the potential for future remedial action costs if the alternative remedial action in question were to fail; and

G) the potential threat to human health and the environment associated with excavation, transportation, and redisposal, or containment.

Nine evaluation criteria have been developed to address the CERCLA requirements and considerations listed above as well as additional technical and policy considerations that have proven to be important for selecting among remedial alternatives. These evaluation criteria serve as the basis for conducting the detailed analyses during the FS and for

subsequently selecting an appropriate remedial action. The evaluation criteria and associated statutory considerations are:

- o Short-term effectiveness (D,G)
- o Long-term effectiveness and permanence (A,C,D)
- o Reduction of toxicity, mobility, or volume (C)
- o Implementability
- o Cost (E,F)
- o Compliance with ARARs (B)
- o Overall protection of human health and the environment
- o State acceptance
- o Community acceptance

7.1.2 The Context of Detailed Analysis

The detailed analysis of alternatives follows the development and screening of alternatives and precedes the actual selection of a remedy. As discussed in Chapters 4 and 5, these phases may overlap, with one beginning before another is completed, or they may vary in the level of detail based on the complexity or scope of the problem. The extent to which alternatives are analyzed during the detailed analysis is influenced by the available data, the number and types of alternatives being analyzed, and the degree to which alternatives were previously analyzed during their development and screening.

The evaluations conducted during the detailed analysis phase build on previous evaluations conducted during the development and screening of alternatives. This phase also incorporates any treatability study data and additional site characterization information that may have been collected during the RI.

The results of the detailed analysis provide the basis for identifying a preferred alternative and preparing the proposed plan. Upon completion of the detailed analysis, the FS report, along with the proposed plan, is submitted for public review and comment. The results

of the detailed analysis serve to document the evaluations of alternatives and provide the basis for selecting a remedy.

7.1.3 Overview of the Detailed Analysis

A detailed analysis of alternatives consists of the following components:

- Further definition of each alternative, if appropriate, with respect to the volumes or areas of contaminated media to be addressed, the technologies to be used, and any performance requirements associated with those technologies

- An assessment and a summary of each alternative against the nine evaluation criteria

- A comparative analysis among the alternatives to assess the relative performance of each alternative with respect to each evaluation criterion

Figure 7-1 illustrates the steps in the detailed analysis process.

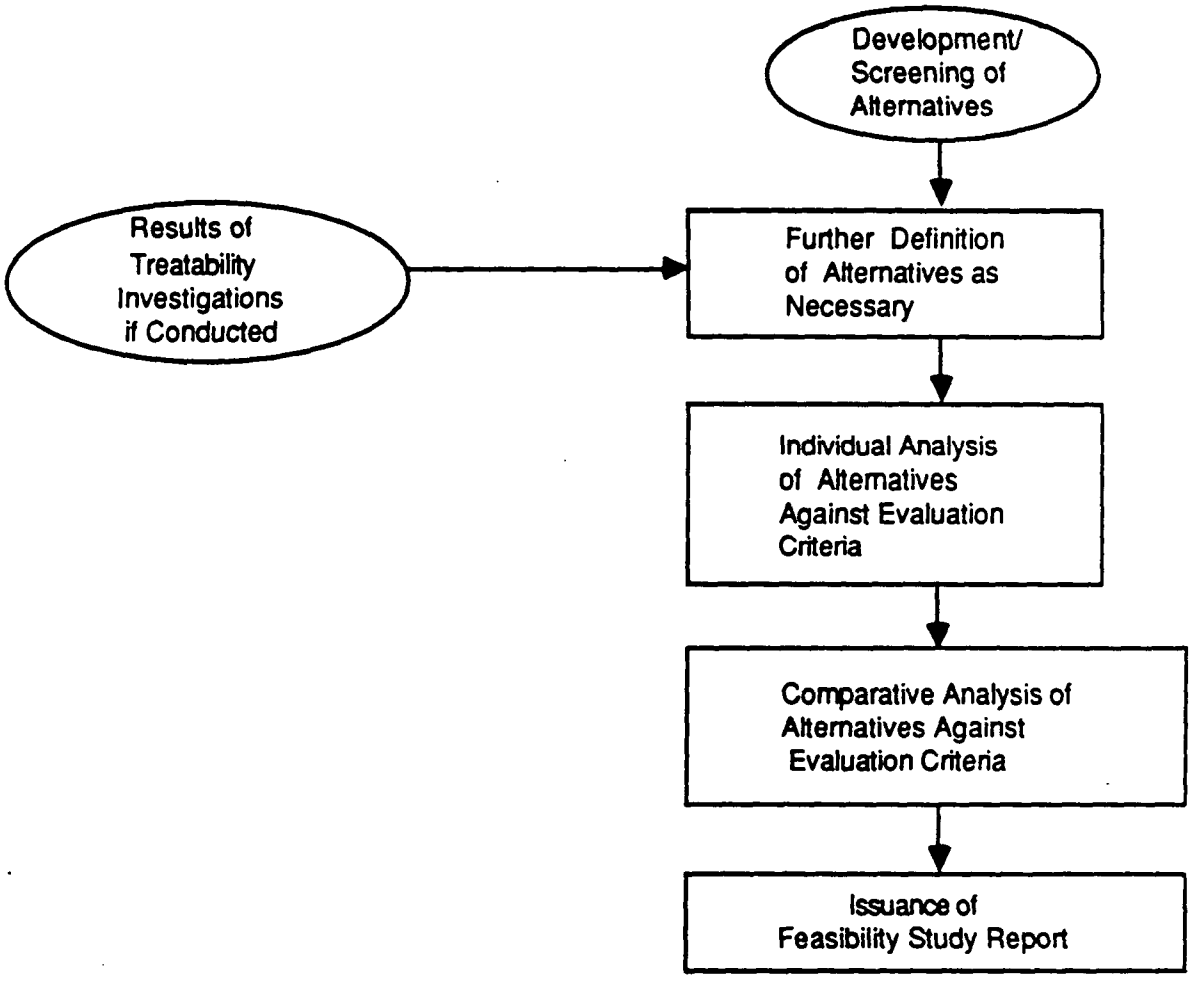
7.2 DETAILED ANALYSIS OF ALTERNATIVES

7.2.1 Alternative Definition

The alternatives that remain after screening may need to be refined more completely prior to the detailed analysis. Alternatives have already been defined during the development and screening phases (see Section 5.2.1) to match contaminated media with appropriate process options; this matching is done by identifying specific remedial response objectives (e.g., a risk-based cleanup target such as $1x10^{-6}$) and sizing process options to attain the objective (e.g., 10 groundwater extraction wells extracting 50 gpm each, activated carbon treatment for 500 gpm). During the detailed analysis, each alternative should be reviewed to

FIGURE 7-1

DETAILED ANALYSIS OF ALTERNATIVES



determine if additional definition is required to apply the evaluation criteria consistently and to develop order-of-magnitude cost estimates (i.e., having a desired accuracy of +50 percent to -30 percent). The following illustrate situations in which additional alternative definition is appropriate:

- The assumed sizing of the process option must be revised on the basis of results of treatability data (e.g., a taller air stripping tower with more packing is required to attain the treatment target).

- A different process option should be used to represent the technology type on the basis of the results of treatability data (e.g., activated carbon rather than air stripping is required).

- The volume of contaminated media has been refined on the basis of additional site characterization data.

The information developed to define alternatives at this stage in the RI/FS process may consist of preliminary design calculations, process flow diagrams, sizing of key process components, preliminary site layouts, and a discussion of limitations, assumptions, and uncertainties concerning each alternative.

As described in Chapter 4, alternatives can be developed and screened on a medium-specific or sitewide basis at the lead agency's discretion. However, during the detailed analysis, the alternatives must be configured to present the decisionmaker with a range of options addressing the entire site or operable unit being addressed by the FS. If separate alternatives have been developed for different areas or media of the site, they should be combined to present a comprehensive remedy that addresses all the potential threats posed by the site or that area being addressed by the operable unit. This can be accomplished either at the beginning of the detailed analysis or

following the analysis when the alternatives are summarized and a comparative analysis is performed.

7.2.2 Overview of Evaluation Criteria

The detailed analysis provides the means by which facts are assembled and evaluated to develop the rationale for a remedy selection. Therefore, it is necessary to understand the requirements of the remedy selection process to ensure that the FS analysis provides the sufficient quantity and quality of information to simplify the transition between the FS report and the actual selection of a remedy. The analysis process described here has been developed on the basis of statutory requirements of CERCLA Section 121, (see Section 7.1.1); earlier program initiatives promulgated in the November 20, 1985, NCP; the existing "Guidance on Remedial Investigations and Feasibility Studies Under CERCLA," dated May 1985; and site-specific experience gained in the Superfund program. The nine evaluation criteria listed in Section 7.1.1 encompass technical, cost, and institutional considerations; compliance with specific statutory requirements; and state and community acceptance.

The five criteria listed below are grouped together because they represent the primary criteria upon which the analysis is based taking into account technical, cost, institutional, and risk concerns.

- Short-term Effectiveness (described in Section 7.2.3.1)--The assessment against this criterion examines the effectiveness of alternatives in protecting human health and the environment during the construction and implementation period until response objectives have been met.

- Long-term Effectiveness and Permanence (described in Section 7.2.3.2)--The assessment of alternatives against this criterion evaluates the long-term effectiveness of alternatives in protecting human health and the environment after response objectives have been met.

- Reduction of Toxicity, Mobility, and Volume (described in Section 7.2.3.3)--The assessment against this criterion evaluates the anticipated performance of the specific treatment technologies.

- Implementability (described in Section 7.2.3.4)--This assessment evaluates the technical and administrative feasibility of alternatives and the availability of required resources.

- Cost (described in Section 7.2.3.5)--This assessment evaluates the capital and O&M costs of each alternative.

The level of detail required to analyze each alternative against these evaluation criteria will depend on the type and complexity of the site, the type of technologies and alternatives being considered, and other project-specific considerations. The analysis should be conducted in sufficient detail such that decisionmakers understand the significant aspects of each alternative and any uncertainties associated with their evaluation (e.g., a cost estimate may have been developed on the basis of a volume of media that could not be precisely defined).

Assessments against two of the criteria relate directly to statutory findings that must ultimately be made in the ROD: compliance with ARARs and overall protection of human health and the environment. These two criteria are briefly described below. Although these assessments draw on information developed under the previous five criteria, they are conducted independently. Generally, these are threshold criteria, in other words, the evaluation of them involves describing whether, and how, each alternative does or does not meet the two criteria.[1]

[1]The actual determination and declaration that these findings have been made is contained in the ROD.

- Compliance with ARARs (described in Section 7.2.3.6)--The assessment against this criterion describes how the alternative complies with ARARs, or if a waiver is required and how it is justified. The assessment includes information from advisories, criteria, and guidance that the lead and support agencies have agreed is necessary and appropriate.

- Overall Protection (described in Section 7.2.3.7)--The assessment against this criterion describes how the alternative, as a whole, protects and maintains protection of human health and the environment.

The final two criteria, state acceptance and community acceptance, should be evaluated to the extent possible on the basis of the information available at the time of the detailed analysis. Because available information on these two criteria will usually be limited or not known at this stage of the RI/FS (i.e., before the public comment period on the proposed plan and the RI/FS), they typically will not be evaluated thoroughly until a final decision is being made and the ROD is being prepared. The criteria are as follows:

- State Acceptance (described in Section 7.2.3.8)--This assessment reflects the state's (or supporting agency's) apparent preferences or concerns about alternatives.

- Community Acceptance (described in Section 7.2.3.9)--This assessment reflects the community's apparent preferences or concerns about alternatives.

Each of the nine evaluation criteria has been further divided into specific factors to allow a thorough analysis of the alternatives. These factors are shown in Table 7-1 and discussed in the following sections.

TABLE 7-1

CRITERIA FOR DETAILED ANALYSIS OF ALTERNATIVES

SHORT-TERM EFFECTIVENESS

- Production of Community During Remedial Actions
- Protection of Workers During Remedial Actions
- Environmental Impacts
- Time Until Remedial Action Objectives Are Achieved

LONG-TERM EFFECTIVENESS

- Magnitude of Residual Risk
- Adequacy of Controls
- Reliability of Controls

REDUCTION OF TOXICITY, MOBILITY, AND VOLUME

- Treatment Process Used and Materials Treated
- Amount of Hazardous Materials Destroyed or Treated
- Degree of Expected Reductions in Toxicity, Mobility, and Volume
- Degree to Which Treatment Is Irreversible
- Type and Quantity of Residuals Remaining After Treatment

IMPLEMENTABILITY

- Ability to Construct and Operate the Technology
- Reliability of the Technology
- Ease of Undertaking Additional Remedial Actions, if Necessary
- Ability to Monitor Effectiveness of Remedy
- Ability to Obtain Approvals From Other Agencies
- Coordination With Other Agencies
- Availability of Offsite Treatment, Storage, and Disposal Services and Capacity
- Availability of Necessary Equipment and Specialists
- Timing of New Technology Under Consideration

COST

- Capital Costs
- Operating and Maintenance Costs
- Present Worth Cost

PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

- How Alternative Provides Human Health and Environmental Protection

COMPLIANCE WITH ARARs

- Compliance With Contaminant-Specific ARARs
- Compliance With Action-Specific ARARs
- Compliance With Location-Specific ARARs
- Compliance With Other Criteria, Advisories, and Guidances

STATE[1] ACCEPTANCE

COMMUNITY[1] ACCEPTANCE

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[1] Only very preliminary assessments of these criteria will be included in the RI/FS. They will be fully assessed in the proposed plan and the ROD.

7.2.3 Individual Analysis of Alternatives

7.2.3.1 Short-term Effectiveness

This evaluation criterion addresses the effects of the alternative during the construction and implementation phase until remedial response objectives are met (e.g., a health-based cleanup target has been met). Under this criterion, alternatives should be evaluated with respect to their effects on human health and the environment during implementation of the remedial action. The following factors of this analysis criterion should be addressed for each alternative:

- Protection of the community during remedial actions--This aspect of short-term effectiveness addresses any risk that results from implementation of the proposed remedial action, such as dust from excavation or air-quality impacts from a stripping tower operation that may affect human health.

- Protection of workers during remedial actions--This factor assesses threats that may be posed to workers and the effectiveness and reliability of protective measures that could be taken.

- Environmental impacts--This factor addresses the potential adverse environmental impacts that may result from the implementation of an alternative and evaluates how effective available mitigation measures would be in preventing or reducing the impacts.

- Time until remedial response objectives are achieved--This factor includes an estimate of the time required to achieve protection for either the entire site or individual elements associated with specific site areas or threats.

Table 7-2 lists appropriate questions to be addressed during the analysis of short-term effectiveness.

7.2.3.2 Long-term Effectiveness and Permanence

The evaluation of alternatives using this criterion addresses the results of a remedial action in terms of the risk remaining at the site after response objectives have been met. The primary focus of this evaluation is the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes. The following components of the criterion should be addressed for each alternative:

- Magnitude of remaining risk--This factor assesses the residual risk remaining from untreated waste or treatment residuals at the conclusion of remedial activities, (e.g., after source/soil containment and/or treatment are complete, or after ground-water plume management activities are concluded). The potential for this risk may be measured by numerical standards such as cancer risk levels or the volume or concentration of contaminants in waste, media, or treatment residuals remaining on the site. The characteristics of the residuals should be considered to the degree that they remain hazardous, taking into account their toxicity, mobility, and propensity to bioaccumulate.

- Adequacy of controls--This factor assesses the adequacy and suitability of controls, if any, that are used to manage treatment residuals or untreated wastes that remain at the site. It may include an assessment of containment systems and institutional controls to determine if they are sufficient to ensure that any exposure to human and environmental receptors is within protective levels.

Table 7-2
SHORT-TERM EFFECTIVENESS

Analysis Factor	Basis for Evaluation During Detailed Analysis
Protection of community during remedial actions	o What are the risks to the community that must be addressed? o How will the risks to the community be addressed and mitigated? o What risks remain to the community that cannot be readily controlled?
Protection of workers during remedial actions	o What are the risks to the workers that must be addressed? o What risks remain to the workers that cannot be readily controlled? o How will the risks to the workers be addressed and mitigated?
Environmental impacts	o What environmental impacts are expected with the construction and implementation of the alternative? o What are the available mitigative measures and their reliability to minimize potential impacts? o What are the impacts that cannot be avoided should the alternative be implemented?
Time until remedial response objectives are achieved	o How long until protection against the threats being addressed by the specific action is achieved? o How long until any remaining site threats will be addressed o How long until remedial response objectives are achieved?

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- Reliability of controls--This factor addresses the long-term reliability of management controls for providing continued protection from residuals. It includes the assessment of the potential need to replace technical components of the alternative, such as a cap, a slurry wall, or a treatment system; the potential exposure pathway; and the risks posed should the remedial action need replacement.

Table 7-3 lists appropriate questions to be addressed during the analysis of long-term effectiveness.

7.2.3.3 Reduction of Toxicity, Mobility, and Volume

This evaluation criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous substances as their principal element. This preference is satisfied when treatment is used to reduce the principal threats at a site through destruction of toxic contaminants, reduction of the total mass of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media.

This evaluation would focus on the following specific factors for a particular remedial alternative:

- The treatment processes, the remedies they will employ, and the materials they will treat

- The amount of hazardous materials that will be destroyed or treated, including how principal threat(s) will be addressed

- The degree of expected reduction in toxicity, mobility, or volume measured as a percentage of reduction (or order of magnitude)

Table 7-3
LONG-TERM EFFECTIVENESS AND PERMANENCE

Analysis Factor	Basis for Evaluation During Detailed Analysis
Magnitude of residual risks	o What is the magnitude of the remaining risks? o What remaining sources of risk can be identified? How much is due to treatment residuals, and how much is due to untreated residual contamination.
Adequacy of controls	o What is the likelihood that the technologies will meet required process efficiencies or performance specifications? o What type and degree of long-term management is required? o What are the requirements for long-term monitoring? o What operation and maintenance functions must be performed? o What difficulties and uncertainties may be associated with long-term operation and maintenance?
Reliability of controls	o What is the potential need for replacement of technical components? o What is the magnitude of the threats or risks should the remedial action need replacement? o What is the degree of confidence that controls can adequately handle potential problems? o What are the uncertainties associated with land disposal of residuals and untreated wastes?

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- o The degree to which the treatment will be irreversible

- o The type and quantity of treatment residuals that will remain following treatment

In evaluating this criterion, an assessment should be made as to whether treatment is used to reduce principal threats, including the extent to which toxicity, mobility, or volume are reduced either alone or in combination. Table 7-4 lists typical questions to be addressed during the analysis of toxicity, mobility, or volume reduction.

7.2.3.4 Implementability

The implementability criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation. This criterion involves analysis of the following factors:

- o Technical feasibility

  - Construction and operation--This relates to the technical difficulties and unknowns associated with a technology. This was initially identified for specific technologies during the development and screening of alternatives and is addressed again in the detailed analysis for the alternative as a whole.

  - Reliability of technology--This focuses on the ability of a technology to meet specified process efficiencies or performance goals. The likelihood that technical problems will lead to schedule delays should be considered as well.

Table 7-4
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME

Analysis Factor	Basis for Evaluation During Detailed Analysis
Treatment process and remedy	o Does the treatment process employed address the principal threats? o Are there any special requirements for the treatment process?
Amount of hazardous material destroyed or treated	o What portion (mass, volume) of contaminated material is destroyed? o What portion (mass, volume) of contaminated material is treated?
Reduction in toxicity, mobility, or volume	o To what extent is the total mass of toxic contaminants reduced? o To what extent is the mobility of toxic contaminants reduced? o To what extent is the volume of toxic contaminants reduced?
Irreversibility of the treatment	o To what extent are the effects of treatment irreversible?
Type and quantity of treatment residual	o What residuals remain? o What are their quantity and characteristics? o What risks do treatment residuals pose?

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- Ease of undertaking additional remedial action--This includes a discussion of what, if any, future remedial actions may need to be undertaken and how difficult it would be to implement such additional actions. This is particularly applicable for an FS addressing an interim action at a site where additional operable units may be analyzed at a later time.

- Monitoring considerations--This addresses the ability to monitor the effectiveness of the remedy and includes an evaluation of the risks of exposure should monitoring be insufficient to detect a system failure.

o Administrative feasibility

- Activities needed to coordinate with other offices and agencies (e.g., obtaining permits for offsite activities or rights-of-way for construction)

o Availability of services and materials

- Availability of adequate offsite treatment, storage capacity, and disposal services

- Availability of necessary equipment and specialists and provisions to ensure any necessary additional resources

- Timing of the availability of technologies under consideration

- Availability of services and materials, plus the potential for obtaining competitive bids, which may be particularly important for innovative technologies.

Table 7-5 lists typical questions to be addressed during the analysis of implementability.

Table 7-5
IMPLEMENTABILITY

Analysis Factor	Basis for Evaluation During Detailed Analysis
Technical Feasibility	
Ability to construct technology	o What difficulties may be associated with construction? o What uncertainties are related to construction?
Reliability of technology	o How reliably does the technology meet specified process efficiencies or performance goals? o What is the likelihood that technical problems will lead to schedule delays?
Ease of undertaking additional remedial action, if necessary	o What likely future remedial actions may be anticipated? o How difficult would it be to implement the additional remedial actions, if required?
Monitoring considerations	o Do migration or exposure pathways exist that cannot be monitored adequately? o What risks of exposure exist should monitoring be insufficient to detect failure?
Administrative Feasibility	
Coordination with other agencies	o What steps are required to coordinate with other agencies? o What steps are required to set up long-term or future coordination among agencies? o Can permits for offsite activities be obtained if required?

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Table 7-5
(continued)

Analysis Factor	Basis for Evaluation During Detailed Analysis
Availability of Services and Materials	
Availability of treatment, storage capacity, and disposal services	o Are adequate treatment, storage capacity, and disposal services available? o How much additional capacity is necessary? o Does the lack of capacity prevent implementation? o What additional provisions are required to ensure the needed additional capacity?
Availability of necessary equipment and specialists	o Are the necessary equipment and specialists available? o What additional equipment and specialists are required? o Do the lack of equipment and specialists prevent implementation? o What additional provisions are required to ensure the needed equipment and specialists?
Availability of prospective technologies	o Are technologies under consideration generally available and sufficiently demonstrated for the specific application? o Will technologies require further development before they can be applied full-scale to the type of waste at the site? o When should the technology be available for full-scale use? o Will more than one vendor be available to provide a competitive bid?

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7.2.3.5 Cost

A comprehensive discussion of costing procedures for CERCLA sites is contained in the Remedial Action Costing Procedures Manual (USEPA, 1985). The application of cost estimates to alternatives evaluation is discussed in the following paragraphs.

Capital Costs. Capital costs consist of direct (construction) and indirect (nonconstruction and overhead) costs. Direct costs include expenditures for the equipment, labor, and materials necessary to install remedial actions. Indirect costs include expenditures for engineering, financial, and other services that are not part of actual installation activities but are required to complete the installation of remedial alternatives. (Sales taxes normally do not apply to Superfund actions.) Costs that must be incurred in the future as part of the remedial action alternative should be identified and noted for the year in which they will occur. The distribution of costs over time will be a critical factor in making tradeoffs between capital-intensive technologies (including alternative treatment and destruction technologies) and less capital-intensive technologies (such as pump and treatment systems).

Direct capital costs may include the following:

- Construction costs--Costs of materials, labor (including fringe benefits and worker's compensation), and equipment required to install a remedial action

- Equipment costs--Costs of remedial action and service equipment necessary to enact the remedy; (these materials remain until the site remedy is complete)

- Land and site-development costs--Expenses associated with the purchase of land and the site preparation costs of existing property

- Buildings and services costs--Costs of process and nonprocess buildings, utility connections, purchased services, and disposal costs

- Relocation expenses--Costs of temporary or permanent accommodations for affected nearby residents. (Since cost estimates for relocations can be complicated, FEMA authorities and EPA Headquarters should be consulted in estimating these costs.)

- Disposal costs--Costs of transporting and disposing of waste material such as drums and contaminated soils

Indirect capital costs may include:

- Engineering expenses--Costs of administration, design, construction supervision, drafting, and treatability testing

- Legal fees and license or permit costs--Administrative and technical costs necessary to obtain licenses and permits for installation and operation

- Startup and shakedown costs--Costs incurred during remedial action startup

- Contingency allowances--Funds to cover costs resulting from unforeseen circumstances, such as adverse weather conditions, strikes, and inadequate site characterization

Annual Costs. Annual costs are post-construction costs necessary to ensure the continued effectiveness of a remedial action. Although some annual costs are borne by the lead agency and others by the support agency, this distinction should not be called out in the FS. The following annual cost components should be considered:

- Operating labor costs--Wages, salaries, training, overhead, and fringe benefits associated with the labor needed for post-construction operations

- Maintenance materials and labor costs--Costs for labor, parts, and other resources required for routine maintenance of facilities and equipment

- Auxiliary materials and energy--Costs of such items as chemicals and electricity for treatment plant operations, water and sewer services, and fuel

- Disposal of residues--Costs to treat or dispose of residuals such as sludges from treatment processes or spent activated carbon

- Purchased services--Sampling costs, laboratory fees, and professional fees for which the need can be predicted

- Administrative costs--Costs associated with the administration of remedial action O&M not included under other categories

- Insurance, taxes, and licensing costs--Costs of such items as liability and sudden accidental insurance; real estate taxes on purchased land or rights-of-way; licensing fees for certain technologies; and permit renewal and reporting costs

- Maintenance reserve and contingency funds--Annual payments into escrow funds to cover costs of anticipated replacement or rebuilding of equipment and any large unanticipated O&M costs

- Rehabilitation costs--Cost for maintaining equipment or structures that wear out over time

- Costs of periodic site reviews--Costs for site reviews that are conducted at least every 5 years if wastes above health-based levels remain at the site

The costs of potential future remedial actions should be addressed, and if appropriate, should be included when there is a reasonable expectation that a major component of the alternative will fail and require replacement to prevent significant exposure to contaminants. Analysis, described under Section 7.2.3.2, "Long-term Effectiveness and Permanence," should be used to determine which alternatives may result in future costs. It is not expected that a detailed statistical analysis will be required to identify probable future costs. Rather, qualitative engineering judgment should be used and the rationale should be well documented in the FS report.

Accuracy of Cost Estimates. Site characterization and treatability investigation information should permit the user to refine cost estimates for remedial action alternatives. It is important to consider the accuracy of costs developed for alternatives in the FS. Typically, these "study estimate" costs made during the FS are expected to provide an accuracy of +50 percent to -30 percent and are prepared using data available from the RI. Costs developed with expected accuracies other than +50 percent to -30 percent should be identified as such in the FS.

Present Worth Analysis. A present worth analysis is used to evaluate expenditures that occur over different time periods by discounting all future costs to a common base year, usually the current year. This allows the cost of remedial action alternatives to be compared on the basis of a single figure representing the amount of money that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the remedial action over its planned life.

In conducting the present worth analysis, assumptions must be made regarding the discount rate and the period of performance. A discount

rate of 5 percent before taxes and after inflation should be assumed. Estimates of costs in each of the planning years are made in constant dollars, representing the general purchasing power at the time of construction. In general, the period of performance should not exceed 30 years for the purpose of the detailed analysis.

Cost Sensitivity Analysis. After the present worth of each remedial action alternative is calculated, individual costs may be evaluated through a sensitivity analysis if there is sufficient uncertainty concerning specific assumptions. A sensitivity analysis assesses the effect that variations in specific assumptions associated with the design, implementation, operation, discount rate, and effective life of an alternative can have on the estimated cost of the alternative. These assumptions depend on the accuracy of the data developed during the site characterization and treatability investigation and on predictions of the future behavior of the technology. Therefore, these assumptions are subject to varying degrees of uncertainty from site to site. The potential effect on the cost of an alternative because of these uncertainties can be observed by varying the assumptions and noting the effects on estimated costs. Sensitivity analyses can also be used to optimize the design of a remedial action alternative, particularly when design parameters are interdependent (e.g., treatment plant capacity for contaminated ground water and the length of the period of performance).

Use of sensitivity analyses should be considered for the factors that can significantly change overall costs of an alternative with only small changes in their values, especially if the factors have a high degree of uncertainty associated with them. Other factors chosen for analysis may include those factors for which the expected (or estimated) value is highly uncertain. The results of such an analysis can be used to identify worst-case scenarios and to revise estimates of contingency or reserve funds.

The following factors are potential candidates for consideration in conducting a sensitivity analysis:

- The effective life of a remedial action
- The O&M costs
- The duration of cleanup
- The volume of contaminated material, given the uncertainty about site conditions
- Other design parameters (e.g., the size of the treatment system)
- The discount rate (5 percent should be used to compare alternative costs, however, a range of 3 to 10 percent can be used to investigate uncertainties)

The results of a sensitivity analysis should be discussed during the comparison of alternatives. Areas of uncertainty that may have a significant effect on the cost of an alternative should be highlighted, and a rationale should be presented for selection of the most probable value of the parameter.

7.2.3.6 Compliance with ARARs

This evaluation criterion is used to determine how each alternative complies with applicable or relevant and appropriate Federal and State requirements, as defined in CERCLA Section 121. There are three general categories of ARARs: chemical-, location-, and action-specific. ARARs for each category have been identified in previous stages of the RI/FS process (e.g., chemical-specific ARARs should be preliminarily identified during scoping of the project). The detailed analysis should summarize which requirements are applicable or relevant and appropriate to

an alternative[1] and describe how the alternative meets these requirements. When an ARAR is not met, the basis for justifying one of the six waivers allowed under CERCLA (see Section 1.2.1.1) should be discussed.

Other information in the form of advisories, criteria, and guidance that are not ARARs may be available, but because they may be necessary to ensure protectiveness and are appropriate for use in a specific alternative they should still be considered in the analysis. These to-be-considered (TBC) criteria should be included in the detailed analysis if the lead and support agencies agree that their inclusion is necessary and appropriate.

The following should be addressed for each alternative during the detailed analysis of ARARs:

- Compliance with chemical-specific ARARs (e.g., MCLs)--This factor addresses whether the ARARs can be met, and if not, whether a waiver may be appropriate.

- Compliance with action-specific ARARs (e.g., RCRA minimum technology standards)--It must be determined whether ARARs can be met or waived.

- Compliance with location-specific ARARs (e.g., preservation of historic sites)--As with other ARAR-related factors, this involves a consideration of whether the ARARs can be met or whether a waiver is appropriate.

- Compliance with appropriate criteria, advisories, and guidances--This involves a consideration of how well the alternative meets Federal and State guidelines that are not ARARs (e.g., not promulgated) but have been identified by lead and

[1]This effort will require the direct involvement of the lead agency as well as input from the support agency.

support agencies as TBCs because they have been determined to be necessary to ensure protection of human health and the environment and are appropriate for the circumstances of the site.

The actual determination of which requirements are applicable or relevant and appropriate is made by the lead agency in consultation with the support agency. A summary of these ARARs and whether they will be attained by a specific alternative should be presented in an appendix to the RI/FS report. A suggested format for this summary is provided in Appendix D of this guidance. More detailed guidance on determining whether requirements are applicable or relevant and appropriate is provided in the "CERCLA Compliance With Other Laws Manual" (U.S. EPA, Draft, November 1987).

7.2.3.7 Overall Protection of Human Health and the Environment

This evaluation criterion provides a final check to assess whether each alternative meets the requirement that it is protective of human health and the environment. The overall assessment of protection is based on a composite of factors assessed under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

Evaluation of the overall protectiveness of an alternative during the RI/FS should focus on how a specific alternative achieves protection over time and how site risks are reduced. The analysis should indicate how each source of contamination is to be eliminated, reduced, or controlled for each alternative.

7.2.3.8 State Acceptance

This assessment evaluates the technical and administrative issues and concerns the state (or support agency in the case of State-lead sites) may have regarding each of the alternatives.

The analysis should be limited to formal comments made during previous phases of the RI/FS and should describe the process used by the lead agency to obtain input from the support agency during preparation of the RI/FS. This may include meetings, opportunities for support-agency review, and the transmittal of comments between agencies.

No formal opportunity is provided for support-agency review of the detailed analysis at this stage in the process. Rather, formal comments can be provided during the comment period on the RI/FS report and proposed plan. These comments will be fully evaluated during preparation of the ROD and the responsiveness summary. To the extent that it is known at the time of the detailed analysis, this criteria should address those features of alternatives that the state (or support agency) supports, has reservations about, or opposes.

7.2.3.9 Community Acceptance

This assessment incorporates public input into the analysis of alternatives. There are several points in the RI/FS process at which the public may have previously provided comments to the lead agency (e.g., comments on the RI report or screening of alternatives). As with the previous assessment of state acceptance, there is no formal opportunity for public comment during the preparation of the RI/FS. Formal public comments are provided during the 30-day public comment period on the RI/FS report and proposed plan. Public concerns or comments will be addressed in the ROD and responsiveness summary. When community positions on specific alternatives has been documented during preparation of the RI/FS, the detailed analysis should address those features the community supports, has reservations about, or opposes.

Section 7.4 discusses community relations activities that should be conducted during the detailed analysis and included in this assessment, as appropriate.

7.2.4 Presentation of Individual Analysis

The analysis of individual alternatives against the nine criteria should be presented in the FS report as a narrative discussion accompanied by a summary table. This information will be used to compare the alternatives and support a subsequent analysis of the alternatives made by the decisionmaker in the remedy selection process. The narrative discussion should, for each alternative, provide (1) a description of the alternative and (2) a discussion of the individual criteria assessment.

The alternative description should provide data on technology components (use of innovative technologies should be identified), quantities of hazardous materials handled, time required for implementation, process sizing, implementation requirements, and assumptions. These descriptions, by clearly articulating the various waste management strategies for each alternative, will also serve as the basis for documenting the rationale of the applicability or relevance and appropriateness of potential Federal and State ARARs. Therefore, the key ARARs for each alternative should be identified and integrated into these discussions.

The narrative discussion of the analysis should, for each alternative, present the assessment of the alternative against each of the nine criteria.[1] This discussion should focus on how, and to what extent, the various factors within each of the nine criteria are addressed. The factors presented in Tables 7-2 through 7-5 have been included to illustrate typical concerns that may need to be addressed

[1] As noted previously information on State acceptance and community acceptance may not be available and therefore these criteria would not be addressed at this time.

Table 7-6
(continued)

Assessment Factors	Alternative 1--No Action	Alternative 2--Containment Capping	Alternative 3--Containment, Onsite RCRA Landfill	Alternative 4--In-Situ Treatment, Vapor Extraction	Alternative 5--Treatment, Incineration Onsite
Long-Term Effectiveness and Permanence					
- Magnitude of residual risk	Significant risk remains from ground-water contamination of 300ug/l TCE onsite. Concentrations of 30 ug/l TCE are projected to occur in 100 residential wells in 10 to 15 years. Risk also remains from contaminated soil and buildings onsite, which may act as a continuing source of dust and ground-water contamination.	Environmental degradation would occur due to migration of contaminated ground water as described for Alternative 1. Potential exists for human exposures due to unauthorized use of contaminated ground water. Potential for risk from soils also exists should the cap fail.	After ground-water extraction and treatment is complete, aquifer will have 10ug/l TCE onsite and <5ug/l offsite. Potential exists for exposure to soil at 76,400 mg/Kg (>10^{-6}), or continued ground-water contamination should the landfill containment system fail.	Treatment of soil and ground water significantly reduces residual site risk. Residual TCE in soil = 64 mg/Kg (10^{-5} to 10^{-6}). Reduced potential for human exposure to soil and/or contaminant migration to ground water. Ground water will have 10ug/l TCE onsite, <5ug/l offsite.	After soils have been incinerated, minor risk remains from treatment residuals remaining onsite. TCE [illegible] in residuals <64mg/Kg [illegible]. Ground-water will be restored to <5ug/l TCE.
			Reduces the potential for direct contact; prevents leaching of contaminants to ground water.		
- Adequacy of controls	No direct engineering controls to prevent exposure to contaminated soil and ground water; fence is susceptible to vandalism; annual inspection and repair is required.	Multimedia cap will reduce the potential for direct contact with contaminated soils and dust; leaching to ground water reduced, but not eliminated; capping is a well-established, proven technology; regular maintenance and inspection is required; cap will probably need replacement in 30 years.	RCRA landfill is a proven technology; annual inspection and maintenance required; ground water offsite will be restored to drinkable quality.	Multimedia cap reduces the potential for direct contact with contaminants remaining in soil; vapor extraction will significantly reduce contaminants in soil, but will require pilot testing; ground water offsite will be restored to drinkable quality.	Incineration is a proven technology; no long-term management of treatment residuals required.
	Ground-water monitoring will track plume movement, but will not remediate contamination.	Ground-water monitoring will track plume movement, but not remediate contamination.	Ground-water monitoring will verify the effectiveness of the extraction system.	Ground-water monitoring will verify the effectiveness of the extraction system, soil treatment, and cap.	Limited monitoring needed to verify ground-water restoration to <5ug/l.
- Reliability of controls	Sole reliance on fence and institutional restrictions to prevent exposure; high level of residual risk; further degradation of ground water likely.	Likelihood of failure is small as long as O&M is performed; risk from direct contact reduced; further degradation of ground water likely.	Likelihood of landfill failure is small as long as O&M is performed; ground-water monitoring needed to verify performance.	Cap failure unlikely; testing needed to verify performance of vapor extraction system.	Remedy will be highly reliable due to removal of material posing a risk.
Reduction of Toxicity, Mobility, or Volume	No reduction in toxicity, mobility, or volume, since no treatment employed.	No reduction in TMV of the soil contamination itself.	Same as Alternative 2 for soil; volume and toxicity of ground-water contamination almost completely remediated by extraction and treatment to 5ug/l offsite.	Toxicity and volume of contaminants in soil significantly reduced by treatment; ground-water contamination same as Alternative 3.	Toxicity and volume of soil and ground-water contamination almost completely eliminated; soil treated to $1x10^{-6}$, ground water to 5ug/l TCE.
Implementability					
- Technical feasibility	Fence is easily constructed; ground-water monitoring would be easy to implement and construct; spread of ground water plume would make remediation more difficult in the future.	Cap and alternate water supply are easily implemented. Spread of ground-water plume would make remediation more difficult to effect in the future.	RCRA landfill relatively easy to implement; staging of soil excavation required; monitoring needed to assess effectiveness of ground-water extraction/treatment; connection of residential wells to municipal water supply still feasible if extraction does not perform as expected.	Soil vapor extraction relatively easy to implement, requires some specialized equipment and specialists for startup; the technology has been demonstrated at sites with similar conditions. Ground water as described in Alternative 3.	Incineration would require special equipment and operators; residuals require testing to verify treatment effectiveness; the technology has been demonstrated at sites with similar conditions. Ground water as described in Alternative 3.

Table 7-6
(continued)

Assessment Factors	Alternative 1--No Action	Alternative 2--Containment Capping	Alternative 3--Containment, Onsite RCRA Landfill	Alternative 4--In-Situ Treatment, Vapor Extraction	Alternative 5--Treatment, Incineration Onsite
Implementability (cont'd)					
- Administrative feasibility	No offsite construction, therefore, no permits required.	Approval for water hook-up needed from municipal water authority.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
- Availability of services and materials	Services and materials locally available.	Same as Alternative 1.	Same as Alternative 1.	Services and materials available, some specialists required for construction and startup.	Mobile incinerator and operators needed; availability from two sources located 500 miles away.
Cost					
- Capital cost	$40,000	$5,610,000	$11,850,000	$10,680,000	$27,860,000
- O&M	$40,000	$50,000	$580,000	$1,600,000	$1,320,000
- Present worth	$200,000	$7,050,000	$16,185,000	$17,900,000	$35,660,000
Compliance with ARARs/TBCS					
- Compliance with ARARs	MCLs in ground water would not be attained.	Aquifer in excess of MCLs. Cumulative risk in excess of 1×10^{-4}.	All ARARS will be met.	All ARARS will be met.	All ARARS will be met.
- Appropriateness of waivers	Not justifiable	Not justifiable	Not required	Not required	Not required
- Compliance with criteria, advisories, and guidance	Does not meet state health department criteria for ground-water quality.	Same as Alternative 1.	Complies with state and local criteria and federal advisories.	Same as Alternative 3.	Same as Alternative 3.
Overall Protection of Human Health and the Environment					
- How risks are eliminated, reduced, or controlled	Risk of direct contact with contaminated soils controlled by fence; risk to human health from dust and ingestion of contaminated ground water is not controlled; environmental degradation will increase as ground-water contamination spreads and leaching from onsite soils continues.	Risk of direct contact with contaminated soils and dust controlled by multimedia cap; risk of ground-water ingestion controlled by alternate water supply and deed restrictions; contaminant migration from onsite soils to ground water controlled by cap but not eliminated; environmental degradation will increase as ground-water contamination continues to spread.	Risk of direct contact with contaminated soils and dust controlled by landfill cap; contaminant migration from onsite soils to ground water significantly reduced by landfill liner and leachate collection system; risk to human health and the environment from ground-water contamination significantly reduced by ground-water extraction and treatment.	Risk of direct contact with contaminated soils and dust significantly reduced by treatment of soil; risk from direct contact to contamination remaining after treatment controlled by multimedia cap. Contaminant migration from onsite soils to ground water significantly reduced by soil treatment and capping; risk to human health and the environment significantly reduced by ground-water extraction and treatment.	Risk of direct contact with contaminated soils and dust eliminated by treatment of soils to 1×10^{-6} risk level; risk to human health and the environment from ground-water contamination permanently eliminated by treatment of soils and ground water.
State Acceptance	To be addressed following public comment.				
Community Acceptance					

during the detailed analysis. It may not be necessary or appropriate to address every factor for each alternative being evaluated and, furthermore it may be useful to address other factors to ensure a better understanding of how an alternative is evaluated against the criteria. The uncertainties associated with specific alternatives should be included when changes in assumptions or unknown conditions could affect the analysis (e.g., the time to attain ground-water cleanup targets may be twice as long as estimated if assumptions made about aquifer characteristics for a specific ground-water extraction alternative are incorrect.)

The FS should also include a summary table highlighting the assessment of each alternative with respect to each of the nine criteria. Table 7-6 provides an example of such a summary prepared for a site at which volatile organic compounds have contaminated soils and an underlying unconsolidated aquifer. In this example, the plume is migrating toward residential water supply wells and is predicted to intercept them in 10 to 15 years.

7.2.5 Comparative Analysis of Alternatives

Once the alternatives have been individually assessed against the nine criteria, a comparative analysis should be conducted to evaluate the relative performance of each alternative in relation to each specific evaluation criterion. This is in contrast to the preceding analysis in which each alternative was analyzed independently without the consideration of interrelationships between alternatives. The purpose of this comparative analysis is to identify the advantages and disadvantages of each alternative relative to one another so that the key tradeoffs to be evaluated by the decisionmaker can be identified.

The first five criteria (short-term effectiveness; long-term effectiveness, and permanence; reduction of toxicity, mobility, and

Table 7-6
SUGGESTED FORMAT FOR SUMMARIZING ALTERNATIVES ANALYSIS

Assessment Factors	Alternative 1--No Action	Alternative 2--Containment Capping	Alternative 3--Containment, Onsite RCRA Landfill	Alternative 4--In-Situ Treatment, Vapor Extraction	Alternative 5--Treatment, Incineration Onsite
	Fence entire site, deed restrictions to prevent onsite development/use; onsite and offsite use of contaminated ground water; ongoing monitoring.	Demolish and shred buildings; place multimedia cap over entire site; fence, deed restrictions; alternate water supply; ongoing monitoring.	Demolish and shred buildings; excavate soil to $1x10^{-6}$ cancer risk; dispose onsite in a RCRA landfill; fence, deed restrictions; collect ground water and treat by air stripping; ongoing monitoring.	Demolish buildings, place rubble onsite; install soil-vapor extraction system and multimedia cap; fence, deed restrictions; collect/treat ground water as in Alternative 3; ongoing monitoring.	Demolish buildings and shreds excavate soil above $1x10^{-6}$ cancer risk; incinerate soil and rubble and dispose of residuals onsite and cap; collect/treat ground water as in Alternative 3.
Short-Term Effectiveness					
- Time until protection is achieved (after ROD signing)	Reduction of potential for direct contact could be achieved in 3 weeks or less; risk from ground-water ingestion remains.	Cap construction could take 2 years, allowing time for design, bidding, construction, and downtime during winter.	RCRA landfill could take 2.5 years for design and construction, allowing time for staging of excavated soils and downtime during winter.	Soil vapor extraction system would take 10 months for pilot testing, design, and construction. The system would be operated for 5 to 8 years after which a multimedia cap, requiring about 18 months to construct, would be placed over the site.	12 to 16 months for trial burn, design, and construction of incinerator; 6.5 years to incinerate 95,500 yd^3 of soil and demolition debris.
		Six months for water connection.	Ground-water collection and treatment system would take up to 12 months for pilot testing, design, and construction. Pumping time of 20 to 30 years would be required to reach the $1x10^{-6}$ cancer risk level in ground water.	Ground-water component as described in Alternative 3.	Ground-water component as described in Alternative 3.
- Protection of community during remedial actions	Slight increase in dust during fence construction.	Increase in dust during cap construction; contaminated soils remain largely undisturbed.	Significant increase in dust from contaminated soils during excavation and staging.	Slight increase in dust during construction of fence and soil vapor extraction system.	Significant increase in dust during excavation and staging.
			Air impacts from stripping tower largely mitigated by emissions control system.	Air impacts from vapor extraction and stripping towers mitigated by emissions control systems.	Air impacts from incinerator mitigated by emissions control system; air impacts from stripping tower mitigated by emissions control system.
- Protection of workers during remedial actions	Protection required against dermal contact and inhalation during fence construction.	Protection required against dermal contact and inhalation of contaminated dust during cap construction.	Protection required against dermal contact and inhalation of contaminated dust during landfill construction. Also, protection needed against dust and vapors during construction and operation of air stripping system.	Protection required against dermal contact, inhalation of dust or vapors during installation, and operation of soil vapor extraction and air stripping systems.	Protection required against dermal contact, inhalation of soils and dust during excavation and staging; protection also required against dust and vapors during startup and operation of incineration and air stripping systems.
- Environmental impacts	No significant adverse environmental impacts from construction	No significant adverse environmental impacts from construction.	Aquifer drawdown during ground-water extraction and treatment (20 to 30 years); minor air impacts from stripping towers.	Same as Alternative 3, plus minor air impacts from soil-vapor extraction system.	Same as Alternative 3, plus potential minor air quality impacts from incinerator emissions.

volume; implementability; and cost) will generally require more discussion than the remaining criteria because the key tradeoffs or concerns among alternatives will most frequently relate to one or more of these five. The overall protectiveness and compliance with ARARs criteria will generally serve as threshold determinations in that they either will or will not be met. Community and state acceptance will likely be evaluated only preliminarily (if at all) during the RI/FS because such information frequently is not available. Community and state acceptance can be addressed more thoroughly once comments on the RI/FS report and the proposed plan have been received and a final remedy selection decision is being made.

7.2.6 Presentation of Comparative Analysis

The comparative analysis should include a narrative discussion describing the strengths and weaknesses of the alternatives relative to one another with respect to each criterion, and how reasonable variations of key uncertainties could change the expectations of their relative performance. If innovative technologies are being considered, their potential advantages in cost or performance and the degree of uncertainty in their expected performance (as compared with more demonstrated technologies) should also be discussed.

The presentation of differences between alternatives can be measured either qualitatively or quantitatively, as appropriate, and should identify substantive differences (e.g., greater short-term effectiveness concerns, greater cost, etc.) between alternatives.[1] Quantitative information that was used to assess the alternatives (e.g., specific cost estimates, time until response objectives would be obtained, and levels of residual contamination) should be included in these discussions.

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[1] Minor differences between alternatives may also need to be highlighted when comparing options providing fairly similar levels of performance and protection.

7.3 POST-RI/FS SELECTION OF THE PREFERRED ALTERNATIVE

Following completion of the RI/FS, the results of the detailed analyses, when combined with the risk management judgments made by the decisionmaker, become the rationale for selecting a preferred alternative and preparing the proposed plan. Therefore, the results of the detailed analysis, or more specifically the comparative analysis, should serve to highlight the relative advantages and disadvantages of each alternative so that the key tradeoffs can be identified. It will be these key tradeoffs compiled with risk management decisions that will serve as the basis for the rationale and provide a transition between the RI/FS report and the development of a proposed plan (and ultimately a ROD). Specific guidance for preparing proposed plans and RODs is provided in the Draft Guidance on preparing Superfund Decision Documents (OSWER Directive number 9355.3-02).

7.4 COMMUNITY RELATIONS DURING DETAILED ANALYSIS

Site-specific community relations activities should be identified in the community relations plan prepared previously. While appropriate modifications of activities may be made to the community relations plan as the project progresses, the plan should generally be implemented as written to ensure that the community is informed of the alternatives being evaluated and is provided a reasonable opportunity to provide input to the decisionmaking process.

Often, a fact sheet is prepared that summarizes the feasible alternatives being evaluated. As appropriate, small group consultations or public meetings may be held to discuss community concerns and explain alternatives under consideration. Public officials should be briefed and press releases prepared describing the alternatives. Other activities identified in the community relations plan should be implemented.

The objective of community relations during the detailed analysis is to assist the community in understanding the alternatives and the specific considerations the lead agency must take into account in selecting a remedial alternative. In this way, the community is prepared to provide meaningful input during the upcoming public comment period.

7.5 REPORTING AND COMMUNICATION DURING DETAILED ANALYSIS

Once the draft RI/FS report is prepared, the lead agency obtains the support agency's review and concurrence, the public's review and comment, and local agency and PRP input, if appropriate. The RI/FS report also provides a basis for remedy selection by EPA (or concurrence on State and Federal facility remedy) and documents the development and analysis of alternatives. A suggested FS report format is given in Table 7-7.

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Table 7-7

SUGGESTED FS REPORT FORMAT

Executive Summary

1 Introduction
- 1.1 Purpose and Organization of Report
- 1.2 Background Information (Summarized from RI Report)
  - 1.2.1 Site Description
  - 1.2.2 Site History
  - 1.2.3 Nature and Extent of Contamination
  - 1.2.4 Contaminant Fate and Transport
  - 1.2.5 Baseline Risk Assessment

2 Identification and Screening of Technologies
- 2.1 Introduction
- 2.2 Remedial Action Objectives--
  Presents the development of remedial action objectives for each medium of interest (i.e., ground water, soil, surface water, air, etc.). For each medium, the following should be discussed:
  - Contaminants of interest
  - Allowable exposure based on risk assessment
  - Allowable exposure based on ARARs
  - Development of remedial action objectives
- 2.3 General Response Actions--
  For each medium of interest, describes the estimation of areas or volumes to which treatment, containment, or exposure technologies may be applied.
- 2.4 Identification and Screening of Technology Types and Process Options--For each medium of interest, describes:
  - 2.4.1 Identification and Screening of Technologies
  - 2.4.2 Evaluation of Technologies and Selection of Representative Technologies

3 Development and Screening of Alternatives
- 3.1 Development of Alternatives--
  Describes rationale for combination of technologies/media into alternatives. Note: This discussion may be by medium or for the site as a whole.
- 3.2 Screening of Alternatives
  - 3.2.1 Introduction
  - 3.2.2 Alternative 1
    - Description
    - Evaluation
    - Effectiveness
    - Implementability
    - Cost

Table 7-7
(continued)

- 3.2.3 Alternative 2
  - Description
  - Evaluation
- 3.2.4 Alternative 3
- 3.2.5 Summary of Screening

4 Detailed Analysis of Alternatives
- 4.1 Introduction
- 4.2 Alternative Analysis
  - 4.2.1 Alternative 1
    - 4.2.1.1 Description
    - 4.2.1.2 Assessment
      - Short-Term Effectiveness
      - Long-Term Effectiveness and Permanence
      - Reduction of Mobility, Toxicity, and Volume
      - Implementability
      - Cost
      - Compliance with ARARs
      - Overall Protection
      - State Acceptance
      - Community Acceptance
  - 4.2.2 Alternative 2
    - 4.2.2.1 Description
    - 4.2.2.2 Assessment
  - 4.2.3 Alternative 3
  - 4.2.4 Summary of Alternatives Analysis
- 4.3 Comparison Among Alternatives
  - 4.3.1 Short-Term Effectiveness
  - 4.3.2 Long-Term Effectiveness and Permanence
  - 4.3.3 Reduction of Toxicity, Mobility, and Volume
  - 4.3.4 Implementability
  - 4.3.5 Cost
  - 4.3.6 Compliance with ARARs
  - 4.3.7 Overall Protection
  - 4.3.4 State Acceptance
  - 4.3.9 Community Acceptance
  - 4.3.10 Summary of comparisons among alternatives
- 4.4 Summary of Detailed Analysis

Bibliography
Appendices

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Appendix A

INTERIM GUIDANCE ON PRP PARTICIPATION IN THE RI/FS PROCESS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
SOLID WASTE AND EMERGENCY RESPONSE

DRAFT

MEMORANDUM

SUBJECT: Interim Guidance on Potentially Responsible Party Participation in Remedial Investigations and Feasibility Studies

FROM: J. Winston Porter
Assistant Administrator

TO: Regional Administrators, Regions I-X
Regional Counsel, Regions I-X
Director, Waste Management Division,
Regions I, IV, V, VII, and VIII
Director, Emergency and Remedial Response Division,
Region II
Director, Hazardous Waste Management Division,
Regions III and VI
Director, Toxics and Waste Management Division,
Region IX
Director, Hazardous Waste Division, Region X

I. INTRODUCTION

This memorandum sets forth the policy and procedures governing the participation of potentially responsible parties (PRPs) in the development of remedial investigations (RI) and feasibility studies (FS) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. This memorandum discusses:

- The initiation of enforcement activities including PRP searches and PRP notification.
- The circumstances in which PRPs may conduct the RI/FS.
- The development of enforceable agreements governing PRP RI/FS activities.

- o Initiation of PRP RI/FS activities and oversight of the RI/FS by EPA.

- o EPA control over PRP RI/FS activities including correction of deficiencies, dispute resolution, and termination of PRP RI/FS activities.

- o PRP participation in Agency RI/FS activities.

More detailed information regarding each of the above topics is included in the attached Appendices.

This document is consistent with CERCLA and EPA guidance in effect as of December 1987, and is intended to supersede the March 20, 1984 memorandum from Assistant Administrators Lee M. Thomas and Courtney M. Price entitled "Participation of Potentially Responsible Parties in Development of Remedial Investigations and Feasibility Studies Under CERCLA" (OSWER Directive No. 9835.1). Users of this guidance should consult the draft "Guidance For Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (March 1988) or any relevant guidance or policies issued after distribution of this document before establishing EPA/PRP responsibilities for conducting RI/FS activities. Additional guidance regarding procedures for EPA oversight activities will be available in the forthcoming EPA "Guidance Manual on Oversight of Potentially Responsible Party Remedial Actions Under CERCLA."

II. BACKGROUND

Sections 104/122 [1] of CERCLA provides PRPs with the opportunity to conduct the RI/FS when EPA determines that, 1) the PRPs are qualified to conduct such activities and 2) that they will carry out the activities in accordance with CERCLA requirements and EPA procedures. It is the policy of EPA to encourage the early and active participation of PRPs in conducting RI/FS activities. To encourage PRP participation, the Agency will continue its policy of early and timely PRP searches as well as early PRP notification and negotiation for RI/FS activities.

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1. The legal authority to enter into agreements with PRPs is found in CERCLA Section 122(a). This section then refers to response actions conducted pursuant to Section 104(b). For the purposes of this guidance, Sections 104/122 will be cited when referring to such authority.

Although EPA encourages PRP participation in conducting the RI/FS, the Agency and CERCLA impose certain conditions governing their participation. These conditions are intended to assure that the RI/FS performed by the PRPs is consistent with Federal requirements and that there is adequate oversight of those activities. These conditions are discussed in Section III of this memorandum and Appendix I, respectively.

At the discretion of EPA, a PRP (or group of PRPs) may assume full responsibility for undertaking RI/FS activities pursuant to Sections 104/122 of CERCLA. The terms and conditions governing the RI/FS activities should be specified in an Administrative Order. The use of Administrative Orders are authorized in CERCLA and are the preferred type of agreement for RI/FS activities since they are authorized internally and therefore, may be negotiated more quickly than Consent Decrees. Before SARA, Administrative Orders were signed using the authorities of Section 106 of CERCLA. New provisions in SARA allow for Orders to be signed using the authorities of Sections 104/122; Section 104/122 Orders do not require EPA to make a finding of imminent and substantial endangerment. RI/FS activities developed subsequent to the Administrative Order are set forth in a Statement of Work, which is then embodied or incorporated in the Order. A Work Plan describing detailed procedures and criteria by which the RI/FS will be performed must be developed by the PRPs and, after approval by EPA, should also be incorporated into the Administrative Order.

It is the responsibility of the lead Agency to ensure the quality of the effort if the PRPs assume responsibility for conducting the RI/FS. Therefore, EPA will establish oversight procedures and project controls to ensure that the appropriateness of response actions are consistent with CERCLA and the National Contingency Plan (NCP). Section 104(a)(1) of CERCLA mandates that no PRP be allowed to undertake and RI/FS unless EPA determines that the party(ies) conducting the RI/FS are qualified to do so and further, that the PRPs agree to reimburse EPA for the costs associated with qualified third party oversight. Third party oversight is required by Section 104(a)(1) and will be provided to assist in overseeing and reviewing the conduct of the RI/FS.

EPA believes that early participation of PRPs in the remedial process will encourage PRP implementation of the selected remedy. PRP participation in RI/FS activities will ensure that they have a better and more complete understanding of the selected remedy, and thus will be more likely to agree on implementation of the remedy. Remedial activities performed by PRPs will also conserve Fund monies, thus making additional resources available to address other sites.

III. INITIATION OF ENFORCEMENT ACTIVITIES

As part of effective management of enforcement activities, timely settlements for RI/FS activities are to be pursued. This includes conducting PRP searches early in the site discovery process and subsequent notification to all PRPs of their potential liability and of their opportunity to perform response activities. Guidance on conducting timely and effective PRP searches is contained in the guidance manual, "Potentially Responsible Party Search Manual" (August 27, 1987 - OSWER Directive No. 9834.6).

EPA policy has been to notify PRPs of their potential liability for the planned response activities, to exchange information about the site, and to provide PRPs with an opportunity to undertake or finance the response activities themselves. In the past this has been accomplished by issuing a "general notice" letter to the PRPs. Section 122(e) of CERCLA now authorizes EPA to use "special notice" procedures which establish a 60 to 90 day moratorium and formal negotiation period. The purpose of the moratorium is to provide time for formal negotiation between EPA and the PRPs for conduct of RI/FS activities. In particular, use of the special notice procedures triggers a 60 day moratorium on EPA conduct of the RI/FS. During the 60 day moratorium, if the PRPs provide EPA with a "good faith offer" to conduct or finance the RI/FS, the negotiation period can be extended to a total of 90 days. EPA considers a "good faith offer" to be a written proposal where the PRPs make a showing of their qualifications and willingness to conduct or finance the RI/FS. Such a showing should include the major elements of a Statement of Work or Work Plan (see Appendix II). Minor deficiencies in the initial submittals should not be grounds for a determination that the offer is not a "good faith offer" or that the PRPs are unable to perform the RI/FS.

To facilitate PRP participation in the RI/FS process, Section 122(e)(1) requires the special notice letter to provide the names and addresses of other PRPs, the volume and nature of substances contributed by each PRP, and a ranking by volume of substances at the site, to the extent this information is available at the time of special notice. Regions are encouraged to release this information to PRPs with the notice letters, to the extent the information is available, when the notice letters are issued. To expedite settlements, Regions are also encouraged to give PRPs as much guidance as possible concerning the RI/FS process. It is appropriate to transmit to PRPs copies of important guidance documents such as the draft "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (March 1988), as well as model Administrative Orders and Statements of Work. A model Administrative Order can be found in

the memorandum from Gene Lucero entitled, "Model CERCLA Section 106 Consent Order for an RI/FS" (January 31, 1985 - OSWER Directive No. 9835.5) and a model Statement of Work is contained as an appendix to the "Guidance on Remedial Investigations Under CERCLA" (June 1985). (The model Order and the model Statement of Work are being revised to reflect SARA requirements and will be forthcoming.) Other Regional and Headquarters guidance relating to technical issues may be given to PRPs, as well as examples of project plans (plans that must be developed for the RI/FS activities) that are of high quality. A description of the required project plans is included in Appendix I.

Although use of the special notice procedures is discretionary, Regions are expected to use these procedures in the majority of cases. If EPA decides not to employ the special notice procedures in Section 122(e) the Agency will notify the PRPs in writing of such a decision, including an explanation as to why EPA believes the use of the special notice procedures is inappropriate. Additional information on the content of special notice letters, including the use of these notice provisions, can be found in the memorandum entitled "Interim Guidance on Notice Letters, Negotiations, and Information Exchange" (October 19, 1987 - OSWER Directive No. 9834.10).

The State must be notified of PRP negotiations; an opportunity for State participation in such negotiations must also be extended. In addition, if a release or threat of release at the site in question may have resulted in damages to natural resources, EPA must notify the appropriate Federal or State Trustee and provide an opportunity for the Trustee to participate in the negotiations. To simplify the notification of Federal Trustees, the Agency intends to provide a list of projects in the Superfund Comprehensive Accomplishments Plan (SCAP) to the Trustees as notice to participate in the negotiations.

IV. CONDITIONS FOR EPA INVOLVEMENT IN AND PRP INITIATION OF RI/FS ACTIVITIES

Under Section 104(a)(1) EPA may authorize PRPs to conduct RI/FS activities at any site, provided the PRPs meet the conditions specified by EPA for conducting the RI/FS. These conditions are discussed in Appendix I of this document and involve the scope of activities, the organization of the PRPs, and the PRPs' (and their contractor's) demonstrative expertise. EPA encourages PRPs to conduct the RI/FS provided that the PRPs commit in an Order (or Consent Decree) under CERLCA Sections 104/122 (or Section 106 for a Decree) to conduct a complete RI/FS to the satisfaction of EPA, under EPA (or State) oversight. Oversight of RI/FS activities by the lead agency is required by

Section 104(a)(1) and is intended to assure that the RI/FS is adequate for lead agency identification of an appropriate remedy, and that it will otherwise meet the Agency requirements of CERCLA, the NCP, and relevant Agency guidance. EPA will allow PRPs to conduct RI/FS activities and will provide review and oversight under the following general circumstances.

EPA's priority is to address those NPL sites that have been identified on the SCAP. The SCAP is an EPA management plan which identifies site- and activity- specific Superfund financial allocations for each quarter of the current fiscal year. When employing Section 122(e) notice procedures, EPA will notify PRPs of its intention to conduct RI/FS activities at NPL sites in a manner that allows at least 90 days notice before obligating the funds necessary to complete the RI/FS (see Section III of this guidance). During this 90-day timeframe PRPs may elect to conduct the RI/FS, under the review and oversight of EPA. If the PRPs agree to conduct the RI/FS they must meet the conditions discussed in Appendix I of this guidance. As mentioned in Section II, Administrative Orders are the preferred type of agreement for RI/FS activities.

EPA will not engage in lengthy discussions with PRPs over whether the PRPs will conduct the RI/FS; in general, EPA will adhere to the timeframes established by the Section 122 special notice provisions. In most instances, once Fund resources have been obligated to conduct the RI/FS, the PRPs will no longer be eligible to conduct the RI/FS activities at the site.

The following actions are taken to initiate RI/FS activities:

- EPA develops a site-specific Statement of Work (SOW) in advance of the scheduled RI/FS start. This SOW is then provided to the PRPs along with a draft of the Administrative Order (or Consent Decree) at the time of special notice. PRPs may, with EPA approval, submit a single project plan that incorporates the elements of a SOW and a detailed Work Plan. This combined site plan must clearly set forth the scope of the proposed RI/FS and would be incorporated into the Order (or Decree) in place of the SOW.

- Final provisions of the SOW are negotiated with the Order (or Decree).

- EPA determines whether the PRPs possess the necessary capabilities to conduct an RI/FS in a timely and effective manner (conducted simultaneously with other negotiations).

- o EPA develops a Community Relations Plan specifying any activities that may be required of the PRPs. (Community relations activities are discussed in Appendix II of this guidance.)

- o EPA determines contractor and staff resources required for oversight and initiates the development of an oversight plan. Initiation of the oversight plan may include preparing a Statement of Work, if a contractor is to develop the oversight plan.

- o EPA and PRPs identify and procure any necessary assistance.

- o PRPs submit a Work Plan to EPA for Agency review and approval. The Work Plan must present detailed procedures and requirements for conducting the RI/FS if such procedures have not been set forth in the Order (or Decree). This Work Plan, which in most instances is one of the first deliverables under the Order (or Decree), is commonly incorporated into the Order (or Decree) following EPA approval.

These standardized actions ensure that the scope of the RI/FS activities to be conducted by the PRPs, and the procedures by which the RI/FS is performed, are consistent with EPA policy and guidance. Additional actions may be required either for a more complex site or for a site where a number of PRPs are involved; regardless of the circumstances, these basic actions should be negotiated as expeditiously as possible. Specific elements of these actions are discussed in Appendix II.

V. DEVELOPMENT OF THE RI/FS ADMINISTRATIVE ORDER OR CONSENT DECREE

The PRPs must respond to EPA's notice letter by either declining, within the time specified to participate in the RI/FS, or by offering a "good faith" proposal to EPA for performing the RI/FS. Declining to participate in the RI/FS may be implied by no response to the notice letter on the part of the PRPs. If the PRPs have declined to participate, or the time specified has lapsed, EPA will obligate funds for performing the RI/FS. If a good faith proposal is submitted, EPA will negotiate with the PRPs on the scope and terms for conducting the RI/FS.

The results of successful negotiations will in most cases be contained in an Administrative Order or where the site is in litigation, in a Judicial Consent Decree entered into pursuant to Section 122(d) of CERCLA. Guidance for the development of an

Administrative Order is provided in the document "Administrative Order: Workshop and Guidance Materials" (U.S. EPA, 1985f), and in the memorandum from Gene Lucero entitled "Model CERCLA Section 106 Consent Order for an RI/FS" (January 31, 1985). (The latter guidance is currently being revised in light of additional SARA requirements.) Before SARA, Administrative Orders were signed using the authorities of Section 106 of CERCLA. New provisions in SARA allow for Orders to be signed using the authorities of Sections 104/122. This is significant because the Agency is no longer required to make a finding of imminent and substantial endangerment when entering into RI/FS agreements under Section 104/122 authorities.

An Administrative Order (or Consent Decree) will generally contain the scope of activities to be performed (either as a Statement of Work or Work Plan), EPA or State oversight roles and responsibilities, and enforcement options that may be exercised (such as stipulated penalties). In addition to the above, the Order (or Decree) will typically include the following elements, as agreed upon by EPA, the PRPs, and other signatories to the Order (or Decree):

- o Jurisdiction. Describes EPA's authority to enter into Administrative Orders or Consent Decrees.

- o Parties bound. Describes to whom the Order (or Decree) applies and is binding upon.

- o Purpose. Describes the purpose of the Order (or Decree) in terms of mutual objectives and public benefit.

- o Findings of fact, determination, and conclusions of law. Provides an outline of facts upon which the Order (or Decree) is based, including the fact that PRPs are not subject to a lesser standard of liability and will not receive preferential treatment from the Agency in conducting the RI/FS.

- o Notice to the State. Verifies that the State has been notified of pending site activities.

- o Work to be Performed. Provides that PRPs submit Project Plans for EPA or State review and approval before commencing RI/FS activities. Project plans are those plans developed for the RI/FS project and include: a Work Plan describing all tasks to be performed during the RI/FS, including the schedules for EPA review and approval procedures as well as a schedule for Work Plan submission and RI/FS implementation; a Sampling and Analysis Plan describing the field sampling to be performed and the

quality assurance procedures which will be followed for sampling and analysis (including a description of how the data gathered during the RI/FS will be managed); and a Health and Safety Plan describing health and safety precautions to be exercised while onsite. (More information on the Project Plans can be found in Appendix II of this guidance.)

- Compliance with CERCLA, the NCP, and Relevant Agency Guidance. Specifies that remedial action at a site will comply with the requirements of CERCLA, the NCP, and relevant Agency guidance determined to be appropriate for site remediation.

- Reimbursement of costs. Specifies that PRPs will assume all costs of performing the work required by the Order (or Decree). In addition, this section commits PRPs to reimbursement of all costs associated with EPA review and oversight activities. This includes reimbursement for third party assistance in oversight, as required by section 104(a)(1). This section should also specify the nature and kind of cost documentation to be provided and the process for billing and receiving payment.

- Reporting. Specifies the type and frequency of reporting that PRPs must provide to EPA. Normally the reporting requirements will, at a minimum include the Work Plan(s), a RI summary, a summary describing the development and screening of alternatives, results of treatability studies, progress reports, and the draft and final RI/FS reports. Additional reporting requirements are left to the discretion of the Regions. That is, Regions may require additional deliverables such as interim reports on particular RI or FS activities.

- Designated EPA, State, and PRP project coordinators. Specifies that EPA, the State, and PRPs shall each designate a project coordinator.

- Site access and data availability. Stipulates that PRPs shall allow access to the site by EPA, the State, and third party oversight officials. Access will be for inspection, review, oversight, and monitoring in any way pertaining to the work undertaken pursuant to the Order (or Decree). In addition, access will be provided in the event of project takeover. This section also stipulates that EPA will be provided with all currently available data.

- Record preservation. Specifies that all records must be maintained by both parties for a minimum of 6 years after termination of the Order (or Decree), followed by a provision requiring PRPs to offer the site records to EPA before destruction.

- Administrative record requirements. Provides that all information upon which the selection of remedy is based must be submitted to EPA in fulfillment of the administrative record requirements pursuant to Section 113 of CERCLA. (Additional information on administrative record requirements is contained in Appendix III of this guidance.)

- Dispute resolution. Specifies steps to be taken if a dispute occurs. The Administrative Order states that with respect to all submittals and work performed, EPA will be the final arbiter while the court is the final arbiter for a Consent Decree. (More information on dispute resolution can be found in Appendix IV of this guidance.)

- Delay in performance/stipulated penalties. Specifies EPA's authority to invoke stipulated penalties for noncompliance with Order or Decree provisions. Section 121 of CERCLA requires that Consent Decrees contain provisions for penalties in an amount not to exceed $25,000 per day. In addition to stipulated penalties, Section 122 provides civil penalties for violations of Administrative Orders and Consent Decrees. Delays that endanger public health and/or the environment may result in termination of the Order or Decree and EPA takeover of the RI/FS. More information on stipulated penalties can be found in the Office of Enforcement and Compliance Monitoring's (OECM) "Guidance on the use of Stipulated Penalties in Hazardous Waste Consent Decrees" (September 21, 1987) and in Appendix IV of this guidance.

- Financial assurance. Specifies that PRPs should have adequate financial resources or insurance coverage to address liabilities resulting from their RI/FS activities. When using contractors, PRPs should certify that the contractors have adequate insurance coverage or that contractor liabilities are indemnified.

- Reservation of rights. States that PRPs are not released from all CERCLA liability through compliance with the Order (or Decree), or completion of the RI/FS. PRPs may be released from liability relating directly to RI/FS requirements, if PRPs complete the RI/FS activities to the satisfaction of EPA.

- o Other claims. Provides that nothing in the Order (or Decree) shall constitute a release from any claim or liability other than, perhaps, for the cost of the RI/FS, if completed to EPA satisfaction. This section should also specify the conditions for indemnification of the U.S. Government.

- o Subsequent modifications/Additional work. Specifies that the PRPs are committed to perform any additional work or subsequent modifications which are not explicitly stated in the Work Plan if EPA determines that such work is needed to enable the selection of an appropriate response action. (Appendix IV of this guidance contains additional information on this clause.)

As part of the Agency's effort to encourage PRP participation in remedial activities, EPA will consider the PRPs' role in conducting RI/FS activities when assessing an overall settlement proposal for the remedial design and remedial action. For example, when the Agency performs a non-binding allocation of responsibility (NBAR), the Agency may consider previous PRP efforts and cooperation. This will provide an additional incentive for PRPs to be cooperative in conducting RI/FS activities.

VI. STATEMENT OF WORK AND WORK PLAN

Based upon available models and guidance, the Region should send a Statement of Work (SOW) to the PRPs with the special notice and draft Administrative Order (or Consent Decree). The SOW describes the broad objectives and general activities to be undertaken in the RI/FS. Once the PRPs receive the SOW they develop a more detailed Work Plan, which is commonly incorporated into the Order (or Decree) following EPA approval.

VII. REVIEW AND OVERSIGHT OF THE RI/FS

To ensure that the RI/FS conforms to the procedures of the NCP and the requirements of CERCLA, including Sections 104(a) and 121, EPA will review and oversee PRP activities. Oversight is also required to ensure that the RI/FS will result in sufficient information to allow for remedy selection by the lead Agency.

An oversight plan should be developed which specifies the activities EPA, the State, and EPA contractors (or other oversight officials) will be performing. Different mechanisms will be used for the review and oversight of different PRP

products and activities. These mechanisms, and corresponding PRP activities, should be specified in the oversight plan. Generally, however, the following oversight activities should be specified:

- o Review of plans, reports, and records by EPA and the State.
- o Oversight of Field activities (including maintenance of records and documentation).
- o Meetings.
- o Special studies.

Section 104(a)(1) requires that the President contract with or arrange for a "qualified person" to assist in the oversight and review of the conduct of the RI/FS. EPA believes that qualified persons, for the purposes of overseeing RI/FS activities, are those firms or individuals with the professional qualifications, expertise, and experience necessary to provide assurance that the Agency is conducting meaningful and effective oversight of PRP activities. In this context, the qualified person generally will be TES contractors, but may also be REM, or ARCs contractors as well as EPA employees, State employees, employees of other Federal agencies, or any other "qualified person" EPA determines to be appropriate to perform the necessary oversight function.

As part of the Section 104 requirements, PRPs are required to reimburse EPA for third party oversight costs. All oversight costs however are recoverable; at a minimum, it is the goal of the Agency to recover all costs of third-party oversight of RI/FS activities. Further guidance on these oversight and project control activities is presented in Appendices III and IV of this guidance, respectively.

VIII. CONTROL OF ACTIVITIES

EPA will usually not intervene in a PRP RI/FS if activities are conducted in conformance with the conditions and terms specified by the Order (or Decree). However, when deficiencies are detected, EPA will take immediate steps to correct the PRP activities. Deficiencies will be corrected through the use of the following activities: (1) identification of the deficiency, (2) demand for corrective measures, (3) use of dispute resolution mechanisms, where appropriate, (4) imposition of penalties, and if necessary, (5) PRP RI/FS termination and project takeover or

judicial enforcement. These activities are described in detail in Appendix IV of this guidance.

IX. PRP PARTICIPATION IN AGENCY-FINANCED RI/FS ACTIVITIES

PRPs that elect not to perform the RI/FS may be allowed involvement in a Fund-Financed RI/FS. Section 113(k)(2)(b) establishes procedures for the participation of interested persons, including PRPs, in the development of the administrative record. PRP participation may include the submittal of information, relevant to the selection of remedy, for inclusion in the record and/or the review of record contents and submittal of comments on such contents. The extent of additional PRP involvement will be left to the discretion of the Region and may include activities such as:

- Access to the site to observe sampling and analysis activities.

- Access to raw data and draft reports.

The Agency continues to encourage PRP participation in Agency-Funded RI/FS to the maximum extent possible. Private parties may possess technical expertise or knowledge about a site which would be useful in developing a sound RI/FS. Involvement by PRPs in the development of a Fund-financed RI/FS may also expedite site cleanup by identifying and satisfactorily resolving differences between the Agency and private parties that might otherwise be the subject of litigation.

The final decision whether to permit PRPs to participate in the Fund-financed RI/FS (as well as the scope of any participation) rests with the Regions. This decision should be based on the ability of PRPs to organize themselves so that they can participate as a single entity, and the ability of PRPs to participate without undue interference with or delay in completion of the RI/FS, and other factors that the Regions determine are relevant. The Region may terminate PRP participation in RI/FS development if unnecessary expenses or delays occur.

X. CONTACT

For further information on the subject matter discussed in this interim guidance, please contact Susan Cange (FTS 475-9805) of the Guidance and Oversight Branch, Office of Waste Programs Enforcement.

APPENDIX I

CONDITIONS FOR PRP CONDUCT OF THE RI/FS

Organization and Management

When several potentially responsible parties are involved at a site they must be able to organize themselves quickly into a single representative body to negotiate with EPA. To facilitate this negotiation process, EPA will make available the names of and addresses of other PRPs, in accordance with the settlement provisions of CERCLA Section 122(e). Either a single PRP or an organized group of PRPs may assume responsibility for development of the RI/FS.

Scope of Activities

As part of the negotiation process PRPs must agree to follow the site-specific Statement of Work (SOW) developed by EPA, including reasonable modifications acceptable to EPA, as the basis for conducting an RI/FS. PRPs are required to submit an RI/FS Work Plan setting forth detailed procedures and tasks necessary to accomplish the RI/FS activities described in the SOW. EPA will reject any request for modifications to the SOW that are not consistent with CERCLA (as amended by SARA), the NCP, the requirements set forth in this guidance document, the draft "Guidance on Remedial Investigations and Feasibility Studies Under CERCLA" (March 1988), or other relevant CERCLA guidance documents.

Demonstrated Capabilities

PRPs must demonstrate to EPA that they possess or are able to obtain the technical expertise necessary to perform all relevant activities identified in the SOW, and any amendments that may be reasonably anticipated to that document. In addition, PRPs must demonstrate that they possess the managerial expertise and have developed a management plan sufficient to ensure that the proposed activities will be properly controlled and efficiently implemented. This management plan should be submitted to EPA for approval either during negotiations or as a part of the Work Plan. As stated previously, a Work Plan describing detailed procedures and criteria by which the RI/FS will be performed is developed by the PRPs after the EPA SOW is developed. The PRP management plan should be equivalent in scope and content to the discussion of roles and responsibilities of key personnel usually contained in the Quality Assurance Project Plan (see the draft "Guidance on Remedial Investigations and Feasibility Studies Under CERCLA" (March 1988)). In addition to demonstrating their managerial qualifications, the PRPs should

demonstrate that they possess the financial capability to conduct and complete the RI/FS in a timely and effective manner. These capabilities are discussed briefly below.

- Demonstrated Technical Capability

PRPs should be required to demonstrate the technical and scientific capabilities of key personnel involved in executing the project. Personnel qualifications may be demonstrated by submitting resumes and references. PRPs should demonstrate the capabilities of the firm or firms that will perform the work by outlining their past areas of business, relevant projects and experience, and overall familiarity with the types of activities to be performed as part of the remedial response.

It is important that qualified firms be retained for performing RI/FS activities. Firms that do not have the necessary expertise for performing RI/FS studies may create unnecessary delays in the project and may create situations which further endanger public health or the environment. These situations may be created when PRP contractors submit insufficient project plans (all plans developed for the RI/FS project), submit deficient reports, or perform inadequate field work. Furthermore, excessive Agency oversight may be required in the event that an unqualified contractor performs the RI/FS; the Agency may have to significantly increase its workload by providing repeated (and oftentimes excessive) reviews of project plans, reports, and oversight of field activities.

- Demonstrated Management Capability

PRPs must demonstrate that they have the administrative capabilities necessary for conducting the RI/FS in a responsible and timely manner. An RI/FS team organization chart should be prepared describing responsibilities and lines of authority. Positions and responsibilities should be clearly related to technical and managerial qualifications. The PRPs should also demonstrate an understanding of effective communications, information management, quality assurance, and quality control systems. If PRPs propose using consultants, the consultants must demonstrate, in addition to those requirements stated above, effective contract management capabilities.

- Demonstrated Financial Capability

The PRPs should develop a comprehensive and reasonable estimate of the total cost of anticipated RI/FS activities. EPA will decide on a case-by-case basis if it will require the PRPs to demonstrate that they have the necessary financial resources

available and committed to conduct the RI/FS activities. The resources estimated should be adequate to cover the anticipated costs for the RI/FS as well as the costs for oversight, plus a margin for unexpected expenses. If, during the conduct of the RI/FS the net worth of the financial mechanism providing funding for the RI/FS is reduced to less than that required to complete the remaining activities, the PRPs should immediately notify EPA. In any event, under conditions specified in the Order (or Decree), PRPs are required to complete the RI/FS regardless of initial cost estimates or financial mechanisms.

o Assistance for PRP Activities

If PRPs propose to use consultants for conducting or assisting in the RI/FS, the PRPs should specify the tasks to be conducted by the consultants and submit personnel and corporate qualifications of the proposed firms to the EPA for review. The PRPs should verify that their consultants have no conflict of interest with respect to the project. Any consultants having current EPA assignments as prime contractors or as subcontractors must obtain approval from their EPA Contract Officers before performing work for PRPs. Lack of clarification on possible conflicts of interest may delay the PRP RI/FS. EPA will reserve the right to review the PRPs proposed selection of contractors and will disapprove their selection if, in EPA's opinion, they do not possess adequate capabilities. It should be noted that the ultimate responsibility for selection of contractors and performance of the RI/FS rests with the PRPs.

APPENDIX II

INITIATION OF PRP RI/FS ACTIVITIES

After the PRPs have been identified in the PRP Search Report and sent the special notice letter, EPA will engage in negotiations with those PRPs who have submitted a good faith offer and are therefore volunteering to perform the RI/FS. As the PRPs are demonstrating their capabilities for conducting the RI/FS, EPA will negotiate the terms of the Administrative Order (or Consent Decree) including, within the Order (or Decree) an acceptable Statement of Work or Work Plan.

Development of the Statement of Work

The Statement of Work (SOW) is developed by EPA and describes, in a comprehensive manner, all RI/FS activities to be performed as reasonably anticipated prior to the onset of the project. The SOW focuses on broad objectives and describes general activities that will be undertaken to achieve these objectives. Detailed procedures by which the work will be accomplished are not presented in the SOW, but are described in the subsequent Work Plan that is developed by the PRPs. In certain instances, with the approval of EPA, PRPs may prepare a single site plan incorporating the elements of a SOW and a Work Plan. In such instances, the site plan will be incorporated into the Order (or Decree) in place of the broader SOW.

- Use of the EPA Model SOW

EPA has developed a model SOW defining a comprehensive RI/FS effort which is contained in the June, 1985 "Guidance on Remedial Investigations under CERCLA." The Regions should develop a site-specific SOW based upon the model and taking into account SARA requirements. RI/FS projects managed by PRPs will involve, at a minimum, all relevant activities set forth in the EPA model SOW. Further, all plans and reports identified as deliverables in the EPA model SOW must be identified as deliverables in the EPA SOW and/or the Work Plan developed by the PRPs. Additional deliverables may be required by the Regions and should be added to the Administrative Order (or Consent Decree).

- Modification of the EPA Draft SOW Requirements

The activities set forth in the model SOW are considered by EPA to be critical RI/FS activities that are required by the NCP. PRPs should present detailed justifications for any proposed modifications and amendments to the activities set forth in the SOW developed for the site by EPA. EPA will review all proposed

modifications and approve or disapprove their inclusion in the SOW based on available information, EPA policy, requirements of the NCP and CERCLA, relevant CERCLA guidance, and overall program objectives. EPA will not allow modifications that, in the judgment of the Agency, will lead to an unsatisfactory RI/FS.

Review of the RI/FS Project Plans

As stated previously, RI/FS project plans include those plans developed for the RI/FS. At a minimum the project plans should include a Work Plan, a Sampling and Analysis Plan, a Health and Safety Plan, and a Community Relations Plan. Review and approval of the RI/FS project plans by EPA will usually be required before PRPs can begin site activities.

o Contents of the Work Plan

The Work Plan expands the tasks of the SOW, and the responsibilities specified in the Agreement, by presenting detailed procedures for conducting the RI/FS. Typically the Work Plan is developed after the draft Order (or Decree) and then incorporated into the Agreement. In some cases however it may be appropriate for EPA to develop the Work Plan prior to actual negotiation with the PRPs and attach the plan to the draft Order (or Decree). The PRP RI/FS Work Plan must be consistent with current EPA guidance. Guidance on developing acceptable Work Plans is available in the draft "Guidance on Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (March 1988). Additional guidance will be forthcoming in the proposed NCP. Once the Work Plan is approved by EPA, it becomes a public document. The Work Plan should, at a minimum, contain the following elements:

Introduction/Background Statement. PRPs should provide an introductory or background statement describing their understanding of the work to be performed at the site. This should include historical site information and should highlight present site conditions.

Description of RI/FS Tasks in Chronological Order. The PRPs should prepare a chronological description of the anticipated RI/FS activities. Important milestones, reports, meetings, and deliverables should be noted. A list of standardized RI/FS tasks has been developed and is available in the guidance entitled "RI/FS Improvements" (July 23, 1987 - OSWER Directive No. 9355.0-20).

o Contents of the Sampling and Analysis Plan

A Sampling and Analysis Plan (SAP) must be submitted by the PRPs before initiation of relevant field activities. This plan contains two separate elements; a Field Sampling Plan and a Quality Assurance Project Plan. These documents were previously submitted as separate deliverables, but are now combined into one document. Though the SAP is typically implemented by PRP contractors, it is the responsibility of the PRPs to ensure that the goals and standards of the plan are met. This document should contain the following elements:

Field Sampling Plan. The Field Sampling Plan includes a detailed description of all RI/FS sampling and analytical activities that will be performed. These activities should be consistent with the NCP and relevant CERCLA guidance. Further guidance on developing Field Sampling Plans is presented in the "Guidance For Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (March 1988).

Quality Assurance Project Plan. The SAP must include a detailed description of QA/QC procedures to be employed during the RI/FS. This section is intended to ensure that the RI/FS is based on the correct level or extent of sampling and analysis required to produce sufficient data for evaluating remedial alternatives for a specific site. A second objective is to ensure the quality of the data collected during the RI/FS. Guidance on appropriate QA/QC procedures may also be found in the draft "Guidance For Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (March 1988). Another publication on this subject is the guidance document, "Data Quality Objectives for the RI/FS Process" (March, 1987 - OSWER Directive No. 9355.0-7B).

If the PRP Work Plan modifies any procedures established in the NCP or relevant guidance, it must provide an explanation and justification for the change.

o Other Project Plans

Other project plans that are likely to be required in the RI/FS process include the Health and Safety Plan and the Community Relations Plan.

Health and Safety Plan. PRPs should include a Health and Safety Plan as part of the Work Plan or as a separate document. The Health and Safety Plan should address the measures taken by the PRPs to ensure that all activities will be conducted in an environmentally safe manner for the

workers and the surrounding community. Guidance on the appropriate contents of a Health and Safety Plan may be found in the draft "Guidance For Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (March 1988).

Community Relations Plan. A Community Relations Plan must be prepared for each NPL site. This plan must be consistent with the NCP and EPA guidance. More information on Community Relations activities is contained below.

o Review and Approval

PRPs must submit all of the required RI/FS project plans to EPA for review and approval. EPA will review the Plans for their technical validity and consistency with the NCP and relevant EPA guidance. Typically, the Agency must review and approve these plans before PRPs can begin any site activities. Any disagreements that arise between EPA and the PRPs over the contents of the plans should be resolved according to the procedures set forth in the dispute resolution section of the relevant EPA/PRP Agreement.

Community Relations

EPA is responsible for developing and implementing an effective community relations program, regardless of whether RI/FS activities are fund-financed or conducted by PRPs. At State-lead enforcement sites, funded by EPA under Superfund Memoranda of Agreement, the State has the responsibility for development and implementation of a community relations program. PRPs may, under certain circumstances, assist EPA or the State in implementing the community relations activities. For example, PRPs may wish to participate in community meetings and in preparing fact sheets. PRP participation in community relations activities would, however, be at the discretion of the Regional Office, or the State, and would require oversight by EPA or the State. EPA will not under any circumstances negotiate press releases with PRPs.

EPA (or the State) design and implement community relations activities according to CERCLA and the NCP. A Community Relations Plan must be developed by EPA for all NPL sites as described by the EPA guidance, "Community Relations in Superfund: A Handbook" (U.S. EPA, 1983a - OSWER Directive No. 9230.0-03) (This guidance is being revised to reflect the new requirements of SARA and will be forthcoming.) The Community Relations Plan must be independent of negotiations with PRPs. Guidance for conducting community relations activities at Superfund enforcement sites is specifically addressed by Chapter VI of the Handbook and the EPA memo entitled "Community Relations

Activities at Superfund Enforcement Sites--Interim Guidance" (U.S. EPA, 1985 - OSWER Directive No. 9230.0-03-a). In some instances the decision regarding PRP participation in community relations activities will be made after the Community Relations Plan has been developed. As a result, the plan will need to be modified by EPA or State staff to reflect Agency and PRP roles and responsibilities.

EPA, or the State, will provide the Community Relations Plan to all interested parties at the same time. In general, if the case has not been referred to the Department of Justice (DOJ) for litigation, community relations activities during the RI/FS should be the same for Fund- and PRP-lead sites. If the case has been (or may potentially be) referred to DOJ for litigation, constraints will likely be placed on the scope of activities. The EPA Community Relations Plan may be modified after consultation with the technical enforcement staff, the Regional Counsel, the Office of Enforcement and Compliance Monitoring, and other negotiation team members, including, if the case is referred, the lead DOJ or Assistant United States Attorneys (i.e, the litigation team). This technical and legal staff must be consulted prior to any public meetings or dissemination of fact sheets or other information; approval must be obtained prior to releases of information and discussions of technical information in advance. PRP participation in implementing community relations activities will be subject to EPA (or State) approval in administrative settlements and EPA/DOJ in civil actions. Key activities specific to community relations programs for enforcement sites include the following:

PRP preparation of Work Plans and public review of Work Plans for Administrative Orders. The PRP Work Plan, as approved by EPA, is incorporated into the Administrative Order (or Consent Decree). Once the Agreement is signed, it becomes a public document. Although there is no requirement for public comment on an Administrative Order, Regional staff are encouraged to announce, after the Order is final, that the PRP is conducting the RI/FS. Publication of notice and a corresponding 30-day comment period is required however, for Consent Decrees. EPA may also consult with community representatives on the PRP Work Plan.

Availability of RI/FS information from the PRPs. PRPs, in agreeing to conduct the RI/FS, must also agree to provide all information necessary for EPA (or the State) to implement a Community Relations Plan. The Order (or Decree) should identify the types of information that PRPs will provide, and contain conditions concerning the provision of this information. EPA should provide the PRPs with the content of the plan so that the PRPs can fully anticipate the type of information that will be made public. All information submitted by PRPs will be subject to public

inspection (i.e., available through Freedom of Information Act requests, public dockets, or the administrative record (if the information is relevant to remedial action decision making)) unless it is deemed either as enforcement sensitive by EPA, or business confidential by PRPs, in conformance with 40 CFR Part 2.

Development of the ATSDR Health Assessment

Section 110 of CERCLA requires the Agency for Toxic Substances and Disease Registry (ATSDR) to perform health assessments at all NPL facilities according to a specified schedule. The purpose of the health assessment is to assist in determining whether any current or potential threat to human health exists and to determine whether additional information on human exposure and associated health risks is needed.

The EPA remedial project manager (RPM) should coordinate with the appropriate ATSDR Regional representative for initiation of the health assessment. In general, the health assessment should be initiated at the start of the RI/FS. The ATSDR Regional representative will provide information on data needs specific to performing a health assessment to ensure that all necessary data will be collected during the RI. The RPM and the ATSDR Regional representative should also coordinate the transmission and review of pertinent documents dealing with the extent and nature of site contamination (i.e., applicable technical memoranda and the draft RI). As ATSDR has no provisions for withholding documents if requested by the public, the RPM must discuss the review of enforcement sensitive documents and drafts with the ATSDR Regional representative rather than to hand them over, to ensure EPA's enforcement confidentiality. Further guidance on coordination of RI/FS activities with ATSDR can be found in the document entitled "Guidance for Coordinating ATSDR Health Assessment Activities with the Superfund Remedial Process" (March, 1987 - OSWER Directive No. 9285.4-02).

Development of the Oversight Plan

EPA will review RI/FS plans and reports as well as provide field oversight of PRP activities during the RI/FS. To ensure that adequate resources are committed and that appropriate activities are performed, the EPA will develop an oversight plan that defines EPA responsibilities, identifies RI/FS products to be reviewed, and lists activities that EPA will oversee. In preparing the plan, EPA should consider such factors as who will be doing the oversight and the schedule of activities that will be monitored. A tracking system for recording PRP milestones and cost estimates should be developed. This system should also track third party activities and other appropriate cost items such as travel needs.

Identification and Procurement of EPA Assistance

In accordance with Section 104(a) EPA must arrange for a third party to assist in oversight of the RI/FS. The following section provides guidance for identifying and procuring such assistance for EPA activities.

- Assistance for EPA Activities

As specified in Section 104(a)(1), EPA is required to contract with or arrange for a qualified person to assist in oversight of the RI/FS. Qualified individuals are those groups with the professional qualifications, expertise, and experience necessary to provide assurance that the Agency is conducting appropriate oversight of PRP RI/FS activities.

Normally, EPA will obtain oversight assistance through the Technical Enforcement Support (TES) contract issued through the Office of Waste Programs Enforcement or occasionally through the Remedial Action (REM) contracts issued through the Office of Emergency and Remedial Response. The latest version of the TES User Guide (January 1986) contains detailed instructions regarding access to these contracts. In some cases oversight assistance may be provided by States through the use of Cooperative Agreements. Oversight assistance may also be obtained through the U.S. Army Corps of Engineers or other governmental agencies. Interagency Agreements should be utilized to obtain such assistance.

APPENDIX III

REVIEW AND OVERSIGHT OF THE RI/FS

Review of Plans, Reports, and Records

EPA will review all RI/FS products which are submitted to the Agency as specified in the Work Plan or Administrative Order (or Consent Decree). PRPs should ensure that all plans, reports, and records are comprehensive, accurate, and consistent in content and format with the NCP and relevant EPA guidance. After this review process, EPA will either approve or disapprove the product. If the product is found to be unsatisfactory, EPA will notify the PRPs of the discrepancies or deficiencies.

o Project Plans

EPA will review all project plans that are submitted as deliverables in fulfillment of the Agreement. These plans include the Work Plan, the Sampling and Analysis Plan (including both the Field Sampling Plan and the Quality Assistance Project Plan), and the Health and Safety Plan. If the initial submittals are not sufficient in content or scope, the RPM will request that the PRPs submit revised document(s) for review. When all required project plans have been reviewed and accepted, EPA will give approval for the PRPs to commence field activities and other tasks designated in the Work Plan.

The PRPs may be required to develop additional Work Plans or modify the initial Work Plan contained in or created pursuant to the Agreement. These changes may result from the need to: (1) re-evaluate the RI/FS activities due to changes in, or unexpected, site conditions, (2) expand the initial Work Plan when additional detail is necessary, or (3) modify or add products to the Work Plan based on new information (e.g., a new population at risk). EPA will review and approve all new Work Plans and modifications as soon as they are developed and submitted for review.

o **Reports**

PRPs will, at a minimum, submit monthly progress reports, technical reports (including a summary of RI activities, a summary of the development and screening of alternatives, and results of treatability studies), and draft and final RI/FS reports as required in the Order (or Decree). To assist in the development of the RI/FS and review of documents, additional deliverables may be specified in the Agreement. These reports and deliverables will be reviewed by EPA to ensure that the

activities specified in the Order (or Decree) and approved Work Plan are being properly implemented. These reports will generally be submitted according to the conditions and schedule set forth in the Agreement. Elements of the PRP reports are discussed below.

Monthly Progress Reports. The review of monthly progress reports is an important activity performed during oversight. These reports should provide sufficient detail to allow EPA to evaluate the past and projected progress of the RI/FS. PRPs should submit these written progress reports to the RPM. The report should describe the actions and decisions taken during the previous month and activities scheduled during the upcoming reporting period. In addition, technical data generated during the month (i.e., analytical results) should be appended to the report. Progress reports should also include a detailed statement of the manner and extent to which the procedures and dates set forth in the Agreement/Work Plan are being met. The draft "Guidance For Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (March 1988) lists suggested procedures for PRPs to use in managing and documenting RI/FS performance through progress reports. Generally, EPA will determine the adequacy of the performance of the RI/FS by reviewing the following subjects discussed in progress reports:

- Technical Summary of Work

The monthly report will describe the activities and accomplishments performed to date. This will generally include a description of all field work completed, such as sampling events and installation of wells; a discussion of analytical results received; and a discussion of data review activities developed for the RI/FS. The report will also describe the activities to be performed during the upcoming month.

- Schedule

EPA will oversee PRP compliance with respect to those schedules specified in the Order (or Decree). Delays, with the exception of those specified under the Force Majeure clause of the Agreement, may result in penalties, if warranted. If PRPs cannot perform required activities or cannot provide the required deliverables specified in the Work Plan, they should notify the RPM by telephone immediately. In addition, PRPs should notify the RPM when circumstances may delay the completion of any phase of the work or when circumstances may delay access to the site. PRPs should also provide to the RPM, in writing, the reasons for, and anticipated duration of, such delays. Any measures taken or to be taken by the PRPs to prevent or minimize the delay should

be described including the timetables for implementing such measures.

o **Budget**

The relationship of budgets to expenditures is to be tracked where the RI/FS is funded with a financial mechanism established by the PRPs. If site activities require more funds than originally estimated, EPA must be assured that the PRPs are financially able to undertake additional expenditures. While EPA does not have the authority to review or approve a PRP budget, it is believed that by evaluating costs during the course of the RI/FS EPA can effectively monitor activity to ensure timely completion of RI/FS activities. If the PRPs run over budget, EPA must be assured that they can continue the RI/FS activities as scheduled. Therefore, PRPs should submit budget expenditures and all cost overrun information to the EPA. Budget reports need not present dollar amounts, but should indicate the relationship between remaining available funds and the estimate of the costs of remaining activities. This information should be included in the PRP monthly progress reports.

o **Problems**

Any problems that the PRPs encounter which could affect the satisfactory performance of the RI/FS should be brought to the immediate attention of EPA. Such problems may or may not be a force majeure event, or caused by a force majeure event. EPA will review problems and advise the PRPs accordingly. Problems which may arise include, but are not limited to:

- Delays in mobilization or access to necessary equipment.
- Unanticipated laboratory/analytical time requirements.
- Unsatisfactory QA/QC performance.
- Requirements for additional or more complex sampling.
- Prolonged unsatisfactory weather conditions.
- Unanticipated site conditions.
- Unexpected, complex community relations activities.

Other Reports. All other reports, such as technical reports and draft and final RI/FS reports, should be submitted to EPA according to the schedule contained in the Order (or Decree) or

the approved Work Plan. EPA will review and approve these reports as they are submitted. Suggested formats for the RI and FS reports are presented in the draft "Guidance for conducting Remedial Investigations and Feasibility studies under CERCLA" (March 1988).

o Records

PRPs should preserve all records, documents, and information of any kind relating to the performance of work at the site for a minimum of six years after completion of the work and termination of the Administrative Order (or Decree). After the six year period, the PRPs should offer the records to EPA before their destruction.

Document control should be a key element of all recordkeeping. The following activities require careful recordkeeping and will be subject to EPA oversight:

Administration. PRP administrative activities should be accurately documented and recorded. Necessary precautions to prevent errors or the loss or misinterpretation of data should be taken. At a minimum, the following administrative actions should be documented and recorded:

- Contractor work plans, contracts, and change orders.
- Personnel changes.
- Communications between and among PRPs, the State, and EPA officials regarding technical aspects of the RI/FS.
- Permit application and award (if applicable).
- Cost overruns.

Technical Analysis. Samples and data should be handled according to procedures set forth in the Sampling and Analysis Plan. Documentation establishing adherence to these procedures should include:

- Sample labels.
- Shipping forms.
- Chain-of-custody forms.
- Field log books.

All analytical data in the RI/FS process should be managed as set

forth in the Sampling and Analysis Plan. Such analytical data may be the product of:

- Contractor laboratories.
- Environmental and public health studies.
- Reliability, performance, and implementability studies of remedial alternatives.

Decision Making. Actions or communications among PRPs that involve decisions affecting technical aspects of the RI/FS should be documented. Such actions and communications include those of the project manager (or other PRP management entity), steering committees, or contractors.

Administrative Record Requirements. Section 113(k) of CERCLA requires that the Agency establish an administrative record upon which the selection of a response action is based. A suggested list of documents which are most likely to be included in any adequate administrative record is provided in the memorandum entitled "Administrative Records for Decisions on Selection of CERCLA Response Actions" (May 29, 1987 - OSWER Directive No. 9833.3). More detailed guidance will be forthcoming, including guidance provided in the revisions to the NCP. There are, however, certain details associated with compiling and maintaining an administrative record that are unique to PRP RI/FS activities.

The information which may comprise the administrative record must be available to the public from the time an RI/FS Work Plan is approved by EPA. From this point on PRPs must transmit to EPA all of the relevant information such as that identified in the above mentioned guidance. The required documentation should be specified in the Administrative Order (or Decree). EPA will compile the administrative record and that record will include all information considered by the Agency, not just the information upon which the Agency relied in the selection of remedy. The Agreement should specify which pre-RI/FS documents must be obtained from the PRPs for inclusion in the record. This may include any previous studies conducted under State or local authorities, management documents held by the PRPs such as hazardous waste shipping manifests, and other information about site characteristics or conditions not contained in any of the above documents.

EPA is responsible for compiling and maintaining the administrative record, and generating and updating an index. If EPA and the PRPs mutually agree, the PRPs may be allowed to house and maintain the administrative record file at or near the site; they may not however be responsible for the actual compilation of the record. Housing and maintaining the administrative record

would include setting up a publicly accessible area at or near the site and ensuring that documents remain and are updated as necessary. EPA must always be responsible for: deciding whether documents are included in the administrative record, transmitting records to the PRPs, and maintaining the index to the repository.

Draft documents which are generated by EPA or their contractors are considered internal Agency documents and are generally not included in the administrative record unless released to outside parties (including PRPs) or in circumstances where there is no final document containing the information considered or relied on by EPA. EPA will consider drafts generated by PRPs or their contractors similarly. Draft documents generated by PRPs conducting the RI/FS will not be included in the record unless they are released to parties other than the participating regulatory agencies. In addition, any information in the draft document that is used for decision making and is not contained elsewhere in the administrative record should be extracted and included in the record.

Field Activities

o Field Inspections

Field inspections are an important oversight mechanism for determining the adequacy of the work performed. EPA will therefore conduct field inspections as part of its oversight responsibilities. The oversight inspections should be performed in a way that minimizes interference with PRP site activities or undue complication of field activities. EPA will take corrective steps, as described in Section VII and Appendix IV, if unsatisfactory performance or other deficiencies are identified.

Several field-related tasks may be performed during oversight inspections. These tasks include:

On-site presence/inspection. As specified in Section 104(e)(3), EPA reserves the right to conduct on-site inspections at any reasonable time. EPA will therefore establish an on-site presence to assure itself of the quality of work being conducted by PRPs. At a minimum, field oversight will be conducted during critical times, such as the installation of monitoring wells and during sampling events. EPA will focus on whether the PRPs adhere to procedures specified in the SOW and Work Plan(s), especially those concerning QA/QC procedures. Further guidance regarding site characterization activities is presented in the NEIC Manual for Groundwater/Subsurface Investigations at Hazardous Waste Sites (U.S. EPA, 1981c), the draft "Guidance For Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (March 1988), the "RCRA Ground Water Technical Enforcement Guidance Document" (September, 1986 - OSWER Directive

No. 9950.1), and the forthcoming "Guidance Manual on Oversight of Potentially Responsible Party Remedial Actions Under CERCLA."

Collection and analysis of samples. EPA may collect a number of QA/QC samples including blank, duplicate, and split samples. The results of these sample analyses will be compared to the results of PRP analyses. This comparison will enable EPA to identify potential quality control problems and therefore help to evaluate the quality of the PRP investigation.

Environmental Monitoring. EPA may supplement any PRP environmental monitoring activity. Such supplemental monitoring may include air or water studies to determine additional migration or sudden releases that may have occurred as a result of site activities.

o QA/QC Audits

EPA may either conduct, or require the PRPs to conduct (if specified in the Agreement), laboratory audits to ensure compliance with proper QA/QC and analytical procedures, as specified in the Sampling and Analysis Plan. These audits will involve on-site inspections of laboratories used by PRPs and analyses of selected QA/QC samples. All procedures must be in accordance with those outlined in The User's Guide to the Contract Laboratory Program, (U.S. EPA, 1986) or otherwise specified in the Sampling and Analysis Plan.

o Chain-of-Custody

Chain-of-custody procedures will be evaluated by EPA. This evaluation will focus on determining if the PRPs and their contractors adhere to the procedures set forth in the Sampling and Analysis Plan. Proper chain-of-custody procedures are described in the draft "Guidance For Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (March 1988) and in the National Enforcement Investigation Center (NEIC) Policies and Procedures Manual, (U.S. EPA, 1981b). Evaluation of chain-of-custody procedures will occur during laboratory audits as well as during on-site inspections of sampling activities.

Meetings

Meetings between EPA, the State, and PRPs should be held on a regular basis (as specified in the Order (or Decree)) and at critical times during the RI/FS. Such critical times may include when the SOW and the Work Plan are reviewed, the RI is completed, remedial alternatives are developed and being screened prior to final analysis, and the draft and final RI/FS reports are submitted. These meetings will discuss overall progress,

discrepancies in the work performed, problems encountered in the performance of RI/FS activities and their resolution, community relations, and other related issues and concerns. While meetings may be initiated by either the PRPs or EPA at any time, they will generally be conducted at the stages of the RI/FS listed below.

- Initiation of Activities

EPA, the State, and the PRPs may meet at various times before field activities begin to discuss the initial planning of the RI/FS. Meetings may be arranged to discuss, review, and approve the SOW; to develop the EPA/PRP Agreement; and to develop, review, and approve the Work Plan.

- Progress

EPA may request meetings to discuss the progress of the RI/FS. These meetings should be held at least quarterly and will focus on the items submitted in the monthly progress reports and the findings from EPA oversight activities. Any problems or deficiencies in the work will be identified and corrective measures (see Section VIII and Appendix IV) will be requested.

- Closeout

EPA may request a closeout meeting upon completion of the RI/FS. This meeting will focus on the review and approval of the final RI/FS report, termination of the RI/FS Agreement, and any final on-site activities which the PRPs may be required to perform. These activities may include maintaining the site and ensuring that fences and warning signs are properly installed. The transition to remedial design and remedial action will also be discussed during this meeting.

Special Studies

EPA may determine that special studies related to the PRP RI/FS are required. These studies can be conducted to verify the progress and results of RI/FS activities or to address a specific complex or controversial issue. Normally, special studies are performed by the PRPs; however, there may be cases in which EPA will want to conduct independent studies. The PRPs should be informed of any such studies and given adequate time to provide necessary coordination of site personnel and resources. If not provided for in the Agreement, modifications to the scope of work, through the addition of a special study, may be required to the Agreement and/or the Work Plan.

APPENDIX IV

CONTROL OF ACTIVITIES

Identification of Deficiencies

Oversight activities may identify unsatisfactory or deficient PRP performance. The determination of such performance may be based upon findings such as:

- o Work products inconsistent with the SOW or Work Plan.
- o Technical deficiencies in submittals or other RI/FS products.
- o Unreasonable delays in performing RI/FS activities.
- o Procedures inconsistent with the NCP.

Corrective Measures

The need to perform corrective measures may arise in the event of deficiencies in reports or other work products or unsatisfactory performance of field or laboratory activities. When deficiencies are identified corrective measures may be sought by: (1) notifying the PRPs, (2) describing the nature of the deficiency, and (3) either requesting the PRPs to take whatever actions they regard as appropriate or setting forth appropriate corrective measures. The following subsections describe this process for each of the two general types of activities that may require corrective measures.

- o Corrective Measures Regarding Work Products

Agency review and approval procedures for work products generally allow three types of responses: (1) approval, (2) approval with modifications, and (3) non-approval. Non-approval of a work product (including project plans) immediately constitutes a notice of deficiency. EPA will immediately notify the PRPs if any work product is not approved and will explain the reason for such a finding.

Approval with modifications will not lead to a notice of deficiency if the modifications are made by the PRPs without delay. If the PRPs significantly delay in responding to the modifications, the RPM should issue a notice of deficiency to the PRP project manager detailing the following elements:

- A description of the deficiency or a statement describing in what manner the work product was found to be deficient or unsatisfactory.

- Modifications that the PRPs should make in the work product to obtain approval.

- A request that the PRPs prepare a plan, if necessary, or otherwise identify actions that will lead to an acceptable work product.

- A schedule for submission of the corrected work product.

- An invitation to the PRPs to discuss the matter in a conference.

- A statement of the possibility of EPA takeover at the PRPs expense, EPA enforcement, or penalties (as appropriate).

o Corrective Measures Regarding Field Activities

When the lead-Agency discovers that the PRPs (or their contractors) are performing the RI/FS field work in a manner that is inconsistent with the Work Plan, the PRPs should be notified of the finding and asked to voluntarily take appropriate corrective measures. The request is generally made at a progress meeting, or, if immediate action is required at a special meeting held specifically to discuss the problem. If corrective measures are not voluntarily taken, the RPM should, in conjunction with appropriate Regional Counsel, issue a notice of deficiency containing the following elements:

- A description of the deficiency.

- A request for an explanation of the failure to perform satisfactorily and a plan for addressing the necessary restoration activities.

- A statement that failure to present an explanation may be taken as an admission that there is no valid explanation.

- Where appropriate, an invitation to discuss the matter in a conference.

- A statement that project termination may occur and/or civil action may by initiated if appropriate actions are not taken to correct the deficiency.

- A description of the potential liabilities incurred in the event that appropriate actions are not taken.

Modifications to the Work Plan/Additional Work

Under the Administrative Order (or Consent Decree), PRPs agree to complete the RI/FS, including the tasks required under either the original Work Plan or the subsequent or modified Work Plan. This may include determinations and evaluations of conditions that are unknown at the time of execution of the Order Agreement. Modifications to the original RI/FS Work Plan are frequently required as field work progresses. Almost uniformly work not explicitly covered in the Work Plan is required and provided for in the Order (or Decree). This work is usually identified during the RI and is driven by the need for further information in a specific area. In general, the Agreement should provide for fine-tuning of the RI, or the investigation of an area previously unidentified. As it becomes clear what additional work is necessary, EPA will notify the PRPs of the work to be performed and determine a schedule for completion of the work.

EPA must ensure that clauses for modifications to the Work Plan are included in the Agreement so that the PRPs will carry out the modifications as the need for them is identified. To facilitate negotiation on these points, EPA may consider one or more of the following provisions in the Order (or Decree) for addressing such situations:

- Specifying the dispute resolution process for modified Work Plans and additional work requirements.

- Defining the applicability of stipulated penalties to any additional work which the PRPs agree to undertake.

- Defining the limits of additional work requirements.

Dispute Resolutions

As discussed elsewhere in this guidance, the RI/FS Order (or Decree) developed between EPA and the PRPs sets forth the terms and conditions for conducting the RI/FS. An element of this Agreement is a statement of the specific steps to be taken if a dispute arises between EPA (or its representatives) and the PRPs. These steps should be well defined and agreed upon by all signatories to the Agreement.

A dispute with respect to the Order (or Decree) is followed by a specific period of discussion with the PRPs. After the discussion period, EPA issues a final decision which becomes incorporated into the Agreement. Administrative Orders should clarify that with respect to all submittals and work performed,

EPA will be the final arbiter. the court, on the other hand, is the final arbiter for Consent Decrees.

Penalties

As an incentive for PRPs to properly conduct the RI/FS and correct any deficiencies discovered during the conduct of the Agreement, EPA should include stipulated penalties. Section 121 provides up to $25,000 per day in stipulated penalties for violations of a Consent Decree while Section 104/122 authorizes EPA to impose civil penalties for violations of Administrative Orders. Penalties should begin to accrue on the first day of the deficiency and continue to be assessed until the deficiency is corrected. The type of violation (i.e, reporting requirements vs. implementation of construction requirements), as well as the amounts, should be specified as stipulated penalties in the Agreement to avoid negotiations on this point which may delay the correction. The amounts should be set pursuant to the criteria of Section 109 and as such should take into account the nature, circumstances, extent, and gravity of the violations as well as the PRPs ability to pay, prior history of violations, degree of culpability, and the economic benefit resulting from noncompliance.

Project Takeover

Generally, EPA will consult with PRPs to discuss deficiencies and corrective measures. If these discussions fail, EPA has two options: (1) pursue legal action to force the PRPs to continue the work, or (2) take over the RI/FS. If taking legal action will not significantly delay implementation of necessary remedial or removal actions, EPA may commence civil action against the noncomplying PRP to enforce the Administrative Order. Under a Consent Decree, the matter would be presented to the court in which the Decree was filed as a motion to enforce the provisions of the Decree.

If a delay in RI/FS activities endangers public health and/or the environment or will significantly delay implementation of necessary remedial actions, EPA should move to replace the PRP activities with Fund-financed actions. The RPM will take the appropriate steps to assume responsibility for the RI/FS, including issuing a stop-work order to the PRPs and notifying the EPA remedial contractors. In issuing stop work orders, RPMs should be aware that Fund resources may not be automatically available. But, in the case of PRP actions which threaten human health or the environment, there may be no other course of action. Once this stop work order is issued, a fund-financed RI/FS will be undertaken consistent with EPA funding procedures.

Appendix D
Documentation of ARARs

ARAR	Alternative 1 No action	Alternative 2 Offsite disposal of waste and contaminated soil/ ground-water extraction and treatment	Alternative 3 Onsite disposal of waste and contaminated soil/ ground-water extraction and treatment	Alternative 4 Onsite soil incineration of waste and contaminated soil/ ground-water extraction and treatment
CHEMICAL SPECIFIC				
TCE	5 ppb Federal MCL is not achieved in ground water	5 ppb Federal MCL is achieved in ground water	5 ppb Federal MCL is achieved in ground water	5 ppb Federal MCL is achieved in ground water
Benzene	5 ppb Federal MCL is not achieved in ground water	5 ppb Federal MCL is achieved in ground water	5 ppb Federal MCL is achieved in ground water	5 ppb Federal MCL is achieved in ground water
Cadmium	10 ppb Federal MCL is not achieved in ground water. 5 ppb State ground water standard is not achieved. 1.1 ppb Federal AWQC is not achieved in surface water	10 ppb Federal MCL is achieved in ground water. 5 ppb State ground water standard is not achieved. 1.1 ppb Federal AWQC is not achieved in surface water. Technical infeasibility waiver is anticipated for both State ground water standard and Federal AWQC	10 ppb Federal MCL is achieved in ground water. 5 ppb State ground water standard is not achieved. 1.1 ppb Federal AWQC is not achieved in surface water. Technical infeasibility waiver is anticipated for both State ground water standard and Federal AWQC	10 ppb Federal MCL is achieved in ground water. 5 ppb State ground water standard is not achieved. 1.1 ppb Federal AWQC is not achieved in surface water. Technical infeasibility waiver is anticipated for both State ground water standard and Federal AWQC
ACTION SPECIFIC				
40 CFR 262 Standards for generators	--	Full compliance with 40 CFR Part 262	Full compliance with 40 CFR Part 262	Full compliance with 40 CFR Part 262
40 CFR 264-265 Standards for owners and operators of hazardous waste treatment, storage, and disposal facilities	Will not comply with 40 CFR 264-265	--	Full compliance with 40 CFR 264-265	Full compliance with 40 CFR 264-265
State air toxics regulations governing emissions of TCE and Benzene	--	Emissions from air stripping unit in full compliance with State air toxics regulations	Emissions from air stripping unit in full compliance with State air toxics regulations	Emissions from air stripping unit and incinerator in full compliance with State air toxics regulations
40 CFR 264 Regulating incineration	--	--	--	Will meet all performance standards for onsite incinerators
LOCATION SPECIFIC				
40 CFR 264.18(b) Location of TSD within 100 year floodplain	--	--	Full compliance with with 40 CFR 264.18(b)	Full compliance with with 40 CFR 264.18(b)
State law governing location of new incinerators	--	--	--	Full compliance with State law

APPENDIX B

ELEMENTS OF RI/FS PROJECT PLANS

B.1 ELEMENTS OF A WORK PLAN

Introduction. Presents a general explanation of the reasons for the RI/FS and the expected results or goals of the RI/FS process.

Site Background and Physical Setting. Describes the current understanding of the physical setting of the site, the site history, and the existing information on the condition of the site. (See Section 2.2.2.1 of guidance)

Initial Evaluation. Presents the conceptual site model developed during scoping describing the potential migration and exposure pathways and the preliminary assessment of public health and environmental impacts. (See Section 2.2.2.2 of the RI/FS guidance)

Work Plan Rationale. Documents data requirements for both the risk assessment and the alternatives evaluation identified during the formulation of the DQOs and presents work plan approach to illustrate how the activities will satisfy data needs.

RI/FS Tasks. The tasks to be performed during the RI/FS are presented. This description incorporates RI site characterization tasks identified in the QAPP and FSP, the data evaluation methods identified during scoping (see Section 2.2.7), and the preliminary determination of tasks to be conducted after site characterization (see Section 2.2.7 of this guidance).

B.2 STANDARD FEDERAL-LEAD RI/FS WORK PLAN TASKS

Task 1. Project Planning

This task includes efforts related to initiating a project after the work assignment is issued. Site survey work may be conducted during project planning or may occur during the field investigation task. It should not occur in both. The project planning task is defined as complete when the work plan and supplemental plans are approved (in whole or in part). The following typical elements are included in this task:

- Work plan memorandum
- Kickoff meeting
- Site visit/meeting
- Easements/permits
- Site reconnaissance and limited sampling
- Site survey/topographic map/review of existing aerial photos
- RI/FS brainstorming session
- Collection and evaluation of existing data
- Identification of preliminary remedial alternatives
- Preliminary risk assessment
- Screening of expedited response alternatives
- Determination of applicable, relevant, and appropriate regulations
- RI scoping
- Preparation of plans (e.g., work plan, health and safety plan, QAPP, FSP)
- Task management and quality control

Task 2. Community Relations

This task incorporates all efforts related to the preparation and implementation of the community relations plan for the site. It includes time expended by both technical and community relations personnel. It will end when community relations work under Task 12 is

completed. This task does not include work on the responsiveness summary (Task 12). The following are typical elements included in this task:

- o Community interviews
- o Community relations plan
- o Fact sheets
- o Public meeting support
- o Technical support for community relations
- o Community relations implementation
- o Task management and quality control

Task 3. Field Investigation

This task involves efforts related to fieldwork in implementing the RI. It includes the procurement of subcontractors related to field efforts. The task begins when any element authorizing fieldwork, as outlined in the work plan, is approved (in whole or in part). Field investigation is defined as complete when the contractor and subcontractors are demobilized from the field. The following activities are typically included in this task:

- o Mobilization
- o Media sampling
- o Source testing
- o Geology/hydrogeological investigations
- o Geophysics
- o Site survey/topographic mapping (if not performed in project planning task)
- o Field screening/analyses
- o Procurement of subcontractors
- o RI waste disposal
- o Task management and quality control

Task 4. Sample Analysis/Validation

This task includes efforts relating to samples after they leave the field. Separate monitoring of close support laboratories may be required. Any efforts associated with laboratory procurement are also included in this task. The task ends on the date that data validation is complete. The following typical activities are usually included in this task:

- o Sample management
- o Non-CLP analyses
- o Use of mobile laboratories
- o Data validation
- o Testing of physical parameters
- o Task management and quality control

Task 5. Data Evaluation

This task includes efforts related to the analysis of data once it has been verified that the data are of acceptable accuracy and precision. The task begins on the date that the first set of validated data is received by the contractor project team and ends during preparation of the RI report when it is deemed that no additional data are required. The following are typical activities:

- o Data evaluation
- o Data reduction and tabulation
- o Environmental fate and transport modeling/evaluation
- o Task management and quality control

Task 6. Assessment of Risks

This task includes efforts related to conducting assessments of risks to human health and the environment. The task will include work under the RI to assess the baseline risks and set preliminary performance goals under the FS, to compare risks evaluated among alternatives. Work

will begin during the data evaluation and end during the remedial alternatives evaluation tasks. The following are typical activities:

- Environmental assessment
- Endangerment assessment
- Modeling specific to exposure assessment
- Task management and quality control

Task 7. Treatability Study/Pilot Testing

This task includes efforts to prepare and conduct pilot, bench, and treatability studies, associated task management, and quality control. The following are typical activities:

- Work plan preparation
- Test facility and equipment procurement
- Vendor and analytical service procurement
- Equipment operation and testing
- Sample analysis and validation
- Report preparation
- Task management and quality control

Task 8. Remedial Investigation Reports

This task covers all efforts related to the preparation of the findings once the data have been evaluated under Tasks 5 and 6. The task covers all draft and final RI reports as well as task management and quality control. The task ends when the last RI document is submitted by the contractor to EPA. The following are typical activities:

- Formatting tables/data presentation
- Writing the report
- Preparing graphics associated with the report
- Reviewing and providing QC efforts

- o Printing and distributing the report
- o Holding review meetings
- o Revising report based on agency comments
- o Providing task management

Task 9. Remedial Alternatives Screening

This task includes efforts to select the alternatives to undergo full evaluation. The task starts during data evaluation when sufficient data are available to begin the screening process. For reporting purposes, the task is defined as complete when a final set of alternatives is chosen for detailed evaluation. The following are typical activities:

- o Listing potential technologies
- o Screening technologies
- o Assembling potential alternatives
- o Evaluating each alternative based on screening criteria
- o Reviewing and providing QC of work effort
- o Preparing report or technical memorandum
- o Holding review meetings
- o Refining list of alternatives to be evaluated

Task 10. Remedial Alternatives Evaluation

This task applies to the detailed analysis and comparison of alternatives. The evaluation activities include performing detailed public health, environmental, and institutional analyses. The task ends with the start of the preparation of the FS report. The following are typical activities:

- o Technical evaluation of each alternative
- o Public health evaluation of each alternative
- o Environmental evaluation of each alternative
- o Institutional evaluation of each alternative

- o Cost evaluation of each alternative
- o Comparison of alternatives
- o Review of QC efforts
- o Review meetings
- o Task management and quality control

Task 11. Feasibility Study/RI/FS Reports

Similar to the RI reports task, this task is used to report FS deliverables. However, this task should be used in lieu of the RI reports task to report costs and schedules for combined RI/FS deliverables. The task ends when the FS (or RI/FS) is released to the public. The following are typical activities:

- o Formatting tables/data presentation
- o Preparing graphics associated with the report
- o Writing the report
- o Printing and distributing the report
- o Holding review meetings
- o Revising the report on the basis of agency comments
- o Providing task management and quality control

Task 12. Post RI/FS Support

This task includes efforts to prepare the responsiveness summary, support the ROD, conduct any predesign activities, and close out the work assignment. All activities occurring after the release of the FS to the public should be reported under this task. The following are typical activities:

- o Preparing the predesign report
- o Preparing the conceptual design
- o Attending public meetings
- o Writing and reviewing the responsiveness summary
- o Supporting ROD preparation and briefings

- o Reviewing and providing QC of the work effort
- o Providing task management and quality control

Task 13. Enforcement Support

This task includes efforts during the RI/FS associated with enforcement aspects of the project. Activities vary but are to be associated with efforts related to potentially responsible parties. The following are typical activities:

- o Reviewing PRP documents
- o Attending negotiation meetings
- o Preparing briefing materials
- o Assisting in the preparation of EDD
- o Providing task management and quality control

Task 14. Miscellaneous Support

This task is used to report on work that is associated with the project but is outside the normal RI/FS scope of work. Activities will vary but include the following:

- o Specific support for review of ATSDR activities
- o Special efforts related to public health assessments
- o Support for review of special state or local projects

Task 15. ERA Planning

This task is to be used specifically for planning expedited response actions (ERAs) after the appropriate remedial action is selected. Activities will fall into the two major categories of administrative support and technical support. The following are typical activities:

- o Drafting and supporting preparation of action memorandums

- Preparing briefing materials
- Attending meetings
- Preparing ERA plans and specifications
- Preparing procurement activities
- Reviewing proposals

Note: The following are some specific comments applicable to the 15 tasks described above:

- All standard tasks or all work activities under each task need not be used for every RI/FS. Only those that are relevant to a given project should be used.

- Tasks include both draft and final versions of deliverables unless otherwise noted.

- The phases of a task should be reported in the same task (e.g., field investigation Phase I and Phase II will appear as one field investigation task).

- If an RI/FS is divided into distinct operable units (OUs), each OU should be monitored and reported on separately. Therefore, an RI/FS with several OUs may, in fact, have more than 15 tasks, although each of the tasks will be one of the 15 standard tasks.

- Costs associated with project management and technical quality assurance are included in each task.

- Costs associated with procuring subcontractors are included in the task in which the subcontractor will perform work (not the project planning task).

- This list of standard tasks defines the minimum level of reporting. For Federal-lead tasks, some RPMs and REM

contractors currently report progress in a more detailed fashion and may continue to do so as long as activities are associated with standard tasks.

B.3 ELEMENTS OF A QUALITY ASSURANCE PROJECT PLAN

Title Page. At the bottom of the title page, provisions should be made for the signatures of approving personnel. As a minimum, the QAPP must be approved by the following:

- o Subcontractor's project manager (if a subcontractor is used)
- o Subcontractor's QA manager (if a subcontractor is used)
- o Contractor's project manager (if applicable)
- o Contractor's QA manager (if applicable)
- o Lead agency's project officer
- o Lead agency's QA officer (if applicable)

Provision should be made for the approval or review of others (e.g., regional laboratory directors), if applicable.

Table of Contents. The table of contents will include an introduction, a serial listing of the 16 QAPP elements, and a listing of any appendixes that are required to augment the QAPP. The end of the table of contents should include a list of the recipients of official copies of the QAPP.

Project Description. The introduction to the project description consists of a general paragraph identifying the phase of the work and the general objectives of the investigation. A description of the location, size, and important physical features of the site such as ponds, lagoons, streams, and roads should be included (a figure showing the site location and layout would be helpful). A chronological site history including descriptions of the use of the site, complaints by neighbors, permitting, and use of chemicals needs to be provided along with a brief summary of previous sampling efforts and an overview of the

results. Finally, specific project objectives for this phase of data gathering need to be listed, and ways in which the data will be used to address each of the objectives must be identified. However, those items above that are also included in the work plan need not be repeated in the QAPP and, instead, may be incorporated by reference.

Project Organization and Responsibilities. This element identifies key personnel or organizations that are necessary for each activity during the study. A table or chart showing the organization and line authority should be included. When specific personnel cannot be identified, the organization with the responsibility should be listed.

QA Objectives for Measurement. For individual matrix groups and parameters, a cooperative effort should be undertaken by the lead agency, the principal engineering firm, and the laboratory staff to define what levels of quality should be required for the data. These QA objectives will be based on a common understanding of the intended use of the data, available laboratory procedures, and available resources. The field blanks and duplicate field sample aliquots to be collected for QA purposes should be itemized for the matrix groups identified in the project description.

The selection of analytical methods requires a familiarity with regulatory or legal requirements concerning data usage. Any regulations that mandate the use of certain methods for any of the sample matrices and parameters listed in the project description should be specified.

The detection limits needed for the project should be reviewed against the detection limits of the laboratory used. Special attention should be paid to the detection limits provided by the laboratory for volatile organic compounds, because these limits are sometimes insufficient for the analysis of drinking water. Detection limits may also be insufficient to assess attainment of ARARs. For Federal-lead projects, if QA objectives are not met by CLP Routine Analytical

Services (RAS), then one or more CLP Special Analytical Services (SAS) can be written.

Quantitative limits should be established for the following QA objectives:

1. Level of QA effort
2. Accuracy of spikes, reference compounds, and so forth
3. Precision
4. Method detection limits

These limits may be specified by referencing the statement of work (SOW) for CLP analysis, including SAS requests, in an appendix and referring to the appendix or owner/operator manuals for field equipment.

Completeness, representativeness, and comparability are quality characteristics that should be considered during study planning. Laboratories should provide data that meet QC acceptance criteria for 90 percent or more of the requested determinations. Any sample types, such as control or background locations, that require a higher degree of completeness should be identified. "Representativeness" of the data is most often thought of in terms of collection of representative samples or selection of representative sample aliquots during laboratory analysis. "Comparability" is a consideration during planning to avoid having to use data gathered by different organizations or among different analytical methods that cannot be reasonably compared because of differences in sampling conditions, sampling procedures, etc.

Sampling Procedures. These procedures append the site-specific sampling plan. Either the sampling plan or the analytical procedures element may document field measurements or test procedures for hydrogeological investigations.

For each major measurement, including pollutant measurement systems, a description of the sampling procedures to be used should be provided. Where applicable, the following should be included:

- A description of techniques or guidelines used to select sampling sites
- A description of the specific sampling procedures to be used
- Charts, flow diagrams, or tables delineating sampling program operations
- A description of containers, procedures, reagents, and so forth, used for sample collection, preservation, transport, and storage
- A discussion of special conditions for the preparation of sampling equipment and containers to avoid sample contamination
- A description of sample preservation methods
- A discussion of the time considerations for shipping samples promptly to the laboratory
- Examples of the custody or chain-of-custody procedures and forms
- A description of the forms, notebooks, and procedures to be used to record sample history, sampling conditions, and analyses to be performed

The DQO document described above can also be incorporated by reference in this section. In addition, the Compendium of Superfund Field Operations Methods (EPA/SAO/P-87/001a, OSWER Directive 9355.0-14)

contains information pertinent to this section and can be incorporated by reference.

Sample Custody. Sample custody is a part of any good laboratory or field operation. If samples may be needed for legal purposes, chain-of-custody procedures, as defined by the NEIC Policies and Procedures (EPA-330/9-78-001-R, revised June 1985), will be used. Custody is divided into three parts:

- Sample collection
- Laboratory
- Final evidence files

The QAPP should address all three areas of custody and should refer to the CLP User's Guide and Regional guidance documents for examples and instructions. For Federal-lead projects, laboratory custody is described in the CLP SOW; this may be referenced. Final evidence files include all originals of laboratory reports and are maintained under documented control in a secure area.

A sample or an evidence file is under custody if:

- It is in your possession.
- It is in your view, after being in your possession.
- It was in your possession and you placed it in a secure area.
- It is in a designated secure area.

A QAPP should provide examples of chain-of-custody records or forms used to record the chain of custody for samples, laboratories, and evidence files.

Calibration Procedures. These procedures should be identified for each parameter measured and should include field and laboratory testing. The appropriate standard operating procedures (SOP) should be

referenced, or a written description of the calibration procedures to be used should be provided.

Analytical Procedures. For each measurement, either the applicable SOP should be referenced or a written description of the analytical procedures to be used should be provided. Approved EPA procedures or their equivalent should be used.

Data Reduction, Validation, and Reporting. For each measurement, the data reduction scheme planned for collected data, including all equations used to calculate the concentration or value of the measured parameter, should be described. The principal criteria that will be used to validate the integrity of the data during collection and reporting should be referenced from Functional Guidelines for Evaluating Organics Analyses (EPA 68-01-6699) and Functional Guidelines for Evaluating Inorganics Analyses (Ref.).

Internal Quality Control. All specific internal quality control methods to be used should be identified. These methods include the use of replicates, spike samples, split samples, blanks, standards, and QC samples. Ways in which the quality control information will be used to qualify the field data should be identified.

Performance and Systems Audits. The QAPP should describe the internal and external performance and systems audits that will be required to monitor the capability and performance of the total measurement system. The current CLP Invitation for Bids for organic and inorganic analyses may be referenced for CLP RAS performance and systems audits. The Compendium of Superfund Field Operations Methods may be referenced for routine fieldwork.

The systems audits consist of the evaluation of the components of the measurement systems to determine their proper selection and use. These audits include a careful evaluation of both field and laboratory quality control procedures and are normally performed before or shortly

after systems are operational. However, such audits should be performed on a regular schedule during the lifetime of the project or continuing operation. An onsite systems audit may be required for formal laboratory certification programs.

After systems are operational and are generating data, performance audits are conducted periodically to determine the accuracy of the total measurement system or its component parts. The QAPP should include a schedule for conducting performance audits for each measurement parameter. Laboratories may be required to participate in the analysis of performance evaluation samples related to specific projects. Project plans should also indicate, where applicable, scheduled participation in all other interlaboratory performance evaluation studies.

In support of performance audits, the environmental monitoring systems and support laboratories provide necessary audit materials and devices, as well as technical assistance. These laboratories conduct regular interlaboratory performance tests and provide guidance and assistance in the conduct of systems audits. The laboratories should be contacted if assistance is needed in the above areas.

Preventative Maintenance. A schedule should be provided of the major preventative maintenance tasks that will be carried out to minimize downtime of field and laboratory instruments. Owner's manuals may be referenced for field equipment.

Specific Routine Procedures Used to Assess Data (Precision, Accuracy, and Completeness). The precision and accuracy of data must be routinely assessed for all environmental monitoring and measurement data. The QAPP should describe specific procedures to accomplish this assessment. If enough data are generated, statistical procedures may be used to assess the precision, accuracy, and completeness. If statistical procedures are used, they should be documented.

Corrective Actions. In the context of quality assurance, corrective actions are procedures that might be implemented with respect to samples that do not meet QA specifications. Corrective actions are usually addressed on a case-by-case basis for each project. The need for corrective actions is based on predetermined limits for acceptability. Corrective actions may include resampling or reanalysis of samples and recommending an audit of laboratory procedures. The QAPP should identify persons responsible for initiating these actions, procedures for identifying and documenting corrective actions, and reporting and followup procedures.

Quality Assurance Reports. QAPPs should identify the method to be used to report the performance of measurement systems and data quality. These reports include results of performance audits, results of systems audits, and significant QA problems encountered, along with recommended solutions. The final report for each project must include a separate QA section that summarizes the data quality information contained in the periodic reports.

B.4 ELEMENTS OF A FIELD SAMPLING PLAN

Site Background. If the analysis of existing data is not included in the work plan or QAPP, it must be included in the FSP. This analysis would include a description of the site and surrounding areas and a discussion of known and suspected contaminant sources, probable transport pathways, and other information about the site. The analysis should also include descriptions of specific data gaps and ways in which sampling is designed to fill those gaps.

Sampling Objectives. Specific objectives of a sampling effort that describe the intended uses of data should be clearly and succinctly stated.

Sample Location and Frequency. This section of the sampling plan identifies each sample matrix to be collected and the constituents to be

analyzed. A table may be used to clearly identify the number of samples to be collected along with the appropriate number of replicates and blanks. A figure should be included to show the locations of existing or proposed sample points.

Sample Designation. A sample numbering system should be established for each project. The sample designation should include the sample or well number, the sampling round, the sample matrix (e.g., surface soil, ground water, soil boring), and the name of the site.

Sampling Equipment and Procedures. Sampling procedures must be clearly written. Step-by-step instructions for each type of sampling are necessary to enable the field team to gather data that will meet the DQOs. A list should include the equipment to be used and the material composition (e.g., Teflon, stainless steel) of the equipment.

Sample Handling and Analysis. A table should be included that identifies sample preservation methods, types of sampling jars, shipping requirements, and holding times. SAS requests and CLP SOWs may be referenced for some of this information.

Examples of paperwork and instructions for filling out the paperwork should be included. Use of the CLP requires that traffic reports, chain-of-custody forms, SAS packing lists, and sample tags be filled out for each sample. If other laboratories are to be used, the specific documentation required should be identified.

Provision should be made for the proper handling and disposal of wastes generated onsite. The site-specific procedures need to be described to prevent contamination of clean areas and to comply with existing regulations.

B.5 ELEMENTS OF A HEALTH AND SAFETY PLAN

1. The name of a site health and safety officer and the names of key personnel and alternates responsible for site safety and health

2. A safety and health risk analysis for existing site conditions, and for each site task and operation

3. Employee training assignments

4. A description of personal protective equipment to be used by employees for each of the site tasks and operations being conducted

5. Medical surveillance requirements

6. A description of the frequency and types of air monitoring, personnel monitoring, and environmental sampling techniques and instrumentation to be used

7. Site control measures

8. Decontamination procedures

9. Standard operating procedures for the site

10. A contingency plan that meets the requirements of 29 CFR 1910.120(l)(1) and (l)(2)

11. Entry procedures for confined spaces

WDR272/007

APPENDIX C
BIBLIOGRAPHY OF TECHNOLOGY PROCESS RESOURCE DOCUMENTS

I - CONTAINMENT TECHNOLOGIES

CAPPING

The Asphalt Institute. Nov. 1976. Asphalt in Hydraulics. Manual Series No. 12 (MS-12), The Asphalt Institute.

Brady, N.C. 1974. The Nature and Properties of Soils. 8th Ed., MacMillan, NY.

Brawner, C.O., Ed. 1980. First International Conference on Uranium Mine Waste Disposal. Society of Mining Engineers AIME, NY.

Chamberlain, E.J., and A.J. Gow. 1979. Effect of Freezing and Thawing on the Permeability and Structure of Soils. Engineering Geology, 13, Elsevier Scientific Publishing Co., Amsterdam, The Netherlands, pp. 73-92.

Daniel, D.E., and H.M. Liljestrant, Univ. of Texas. Jan. 1984. Effects of Landfill Leachates on Natural Liner Systems. Chemical Manufacturer's Association.

England, C.B. 1970. Land Capability: A Hydrologic Response Unit in Agricultural Watersheds. ARS 41-172, Agricultural Research Service, U.S. Department of Agriculture.

Ghassemi, M. May 1983. Assessment of Technology for Constructing and Installing Cover and Bottom Liner Systems for Hazardous Waste Facilities. Vol. 1, EPA Contract No. 68-02-3174, work assignment No. 109, U.S. EPA.

Kays, W.B. 1977. Construction of Linings for Reservoirs, Tanks, and Pollution Control Facilities. John Wiley & Sons, NY.

Kmet, P., K.J. Quinn, and C. Slavik. Sept. 1981. Analysis of Design Parameters Affecting the Collection Efficiency of Clay Lined Landfills. Univ. of Wisconsin Extension.

Lambe, W.T., and R.V. Whitman. 1979. Solid Mechanics, SI Version. John Wiley and Sons, NY.

Lutton, R.J. 1982. Evaluating Cover Systems for Solid and Hazardous Waste. SW867 (Revised Edition), U.S. EPA, Washington, DC.

Lutton, R.J. et al. 1979. Design and Construction of Covers for Solid Waste Landfills. EPA-600/2-79-165, U.S. EPA, Cincinnati, OH.

Morrison, W.R., and L.R. Simmons. 1977. Chemical and Vegetative Stabilization of Soil: Laboratory and Field Investigations of New Materials and Methods for Soil Stabilization and Erosion Control. Bureau of Reclamation Report No. 7613.

Oldham, J.C., et al. 1977. Materials Evaluated as Potential Soil Stabilizers. Paper No. S-77-15 Army Engineers, Waterways Experimental Station, Vicksburg, MS.

Richards, L.A. 1965. Physical Condition of Water in Soil. In: Methods of Soil Analysis - Part . C.A. Black, Ed., American Society of Agronomy, Inc.

Schroeder, P.R., et al. The Hydrologic Evaluation of Landfill Performance (HELP) Model. Vol. 1, EPA/530-SW-84-009, U.S. EPA.

Tchobanoglous, G., et al. 1977. Solid Wastes: Engineering Principles and Management Issues. McGraw-Hill, NY.

U.S. EPA. Construction Quality Assurance for Hazardous Waste Land Disposal Facilities. Public Comment Draft, J.G. Herrmann, Project Officer. EPA/530-SW-85-021, U.S. EPA.

U.S. EPA. July 1982. Draft RCRA Guidance Document Landfill Design, Liner Systems and Final Cover. U.S. EPA.

U.S. EPA. 1983. Lining of Waste Impoundment and Disposal Facilities. SW870, U.S. EPA.

U.S. EPA. Procedures for Modeling Flow Through Clay Liners to Determine Required Liner Thickness. EPA/530-SW-84-001, U.S. EPA.

Warner, R.C., et al. Demonstration and Evaluation of the Hydrologic Effectiveness of a Three Layer Landfill Surface Cover Under Stable and Subsidence Conditions - Phase I, Final Project Report.

Warner, R.C., et al. Multiple Soil Layer Hazardous Waste Landfill Cover: Design, Construction, Instrumentation and Monitoring. In: Land Disposal of Hazardous Waste Proceedings of the Tenth Annual Research Symposium.

DUST CONTROLS

Ritter, L.J., Jr., and R.J. Paquette. 1967. Highway Engineering. 3d Ed., The Ronald Press Co., NY. pp. 726-728.

HORIZONTAL BARRIERS

Bureau of Reclamation. Pressure Grouting. Technical Memo 646.

U.S. EPA. Handbook for Evaluating Remedial Action Technology Plans.

SEDIMENT CONTROL BARRIERS

California Department of Conservation. May 1978. Erosion and Sediment Control Handbook. Department of Conservation, State of California.

U.S. EPA. August 1972. Guidelines for Erosion and Sediment Control Planning and Implementation. U.S. EPA, Environmental Protection Technical Services.

U.S. EPA. Sept. 1978. Management of Bottom Sediment Containing Toxic Substance Procedure, 3rd vs - Japan Meeting. U.S. EPA.

U.S. EPA. June 1982. Handbook - Remedial Action at Waste Disposal Sites. EPA-625/6-6-82-006, U.S. EPA, Cincinnati, OH.

SURFACE CONTROLS

Lutton, R.J., et al. 1979. Design and Construction of Covers for Solid Waste Landfills. EPA-600/2-79-165, U.S. EPA Cincinnati, OH.

U.S. EPA. July 1982. Draft RCRA Guidance Document Landfill Design, Liner Systems, and Final Cover. U.S. EPA.

U.S. EPA. June 1982. Handbook - Remedial Action at Waste Disposal Sites. EPA-625/6-6-82-006, U.S. EPA, Cincinnati, OH.

VERTICAL BARRIERS

Bureau of Reclamation. Pressure Grouting. Technical Memo. 646.

Shuster, J. 1972. Controlled Freezing for Temporary Ground Support. Proceedings, 1st North American Rapid Excavation and Tunneling Conference.

Xanthakos, P. Slurry Walls. McGraw Hill, NY.

II - TREATMENT TECHNOLOGIES

AIR EMISSION CONTROLS/GAS TREATMENT

Bonner, T., et al. 1981. Hazardous Waste Incineration Engineering. Noyes Data Corporation.

Kern, D.Q. 1950. Process Heat Transfer. McGraw-Hill, NY.

Kohl, A., and F. Riesenfeld. 1979. Gas Purification. Gulf Publishing Co.

Perry and Chilton Chemical Engineers' Handbook. 5th Ed., 1973, McGraw-Hill, NY.

Research and Education Association. 1978. Modern Pollution Control Technology. Vol. 1, Air Pollution Control. Research and Education Association.

BIOLOGICAL TREATMENT

Beneield, L.D., and C.W. Randall. 1980. Biological Process Design for Wastewater Treatment. Prentice-Hall, Englewood Cliffs, NJ.

Aerobic Biotreatment Reference: Clark, J.W., W. Viessman, Jr., and J. Hammar. 1977. Water Supply and Pollution Control. IEP, Dun-Donnelly, NY.

Eckenfelder, W., Jr. 1980. Principles of Water Quality Management. CBI Publishing, Boston.

Fair, G., J. Geyer, and D. Okun. 1968. Water and Wastewater Engineering. Vol. 2, John Wiley, NY.

Junkins, R., et al. 1983. The Activated Sludge Process: Fundamentals of Operation. Science Publishers, Ann Arbor, MI.

Manual of Practice No. 16, Anaerobic Sludge Digestion. EPCF, 1968.

Metcalf & Eddy. 1972. Wastewater Engineering: Treatment, Disposal, Reuse. 2nd Ed., McGraw-Hill, NY.

Overcash. 1979. Design of Land Treatment Systems for Industrial Wastes.

Shreve, R. N., and J.A. Brink, Jr. 1977. Chemical Process Industries. McGraw-Hill, NY.

Smith, E.D., et al. 1980. Proceedings First National Symposium/ Workshop, Rotating Biological Contractor Technology. University of Pittsburgh.

Speece, R.E., and J.F. Malina, Jr., Eds. 1973. Applications of Commercial Oxygen to Water and Wastewater Systems. Univ. of Texas, Austin.

U.S. EPA. Dec. 1985. Guide for Identifying Cleanup Alternatives at Hazardous-Waste Sites and Spills. EPA/600/3-83/063; NTIS PB86-144664, U.S. EPA.

U.S. EPA. 1980. Hazardous Waste Land Treatment, EPA SW 874, U.S. EPA.

U.S. EPA. Dec. 1984. Permit Guidance Manual on Hazardous Waste Land Treatment Demonstrations. Draft, EPA 530-SW-84-015, U.S. EPA.

U.S. EPA. Process Design Manual, Sludge Treatment and Disposal. U.S. EPA.

U.S. Municipal Environmental Research Laboratory. Oct. 1983. Process Design Manual for Land Application of Municipal Sludge. EPA 625/1-83-016, U.S. EPA.

Vesilind, P.A. Sludge Treatment and Disposal.

CHEMICAL TREATMENT

Audrieth, L.F., and B.A. Ogg. 1951. The Chemistry of Hydrazine. John Wiley, NY.

Berkowitz, J.B., et al. 1978. Unit Operations for Treatment of Industrial Wastes. Noyces Data Corp., Park Ridge, NJ.

Butler, J.W. 1964. Solubility and pH Calculations. Addision-Wesley.

Duffey, J.G., S.B. Gale, and S. Bruckenstein. Electrochemical Removal of Chromates and Other Metals. In: Cooling Towers. Vol. 2, pp 44-50.

Metcalf & Eddy, Inc., revised by Tchobanoglous, G. 1979. Wastewater Engineering: Treatment, Disposal, Reuse. 2nd Ed.

McHugh, M.A., and V.J. Krukonis. 1986. Supercritical Fluid Extraction Principles and Practice. Butterworth Publishers, Boston.

Reduction by Direct Current (Electrochemical Treatment) References: Scull, G.W., and K.D. Uhrich. Electrochemical Removal of Heavy Metals in the Presence of Chelating Agents. Andco Environmental Processes, Inc., Amherst, NY.

Simpson, D.K. Safety Handling Hydrazine. Prepared for the Water Industrial Power Conference, Southfield, MI, Oct. 16-19, 1983.

Tsusita, R.A., et al. 1981. Pretreatment of Industrial Wastes Manual of Practice. No. FD-3, Water Pollution Control Federation, Washington, DC.

IN SITU TREATMENT

Ahlert, R.C., and D.S. Kosson. In-Situ and On-Site Biodegradation of Industrial Landfill Leachate. NTIS, Springfield, VA.

American Petroleum Institute. Feb. 1982. Enhancing the Microbial Degradation of Underground Gasoline by Increasing Available Oxygen. Texas Research Institute.

References on the use of H202 in Subsurface Bioreclamation: American Petroleum Institute. 1985. Feasibility Studies on the Use of Hydrogen Peroxide to Enhance Microbial Degrations of Gasoline. API Publication 4389.

Baker, R., et al. Oct. 1986. In Situ Treatment for Site Remediation. Paper presented at Third Annual Hazardous Waste Law and Management Conference, Seattle, WA, and Portland, OR.

Ellis, W.D., and T.R. Fogg. August 1986. Treatment of Soils Contaminated With Heavy Metals. EPA/600/9-86/022, U.S. EPA, pp. 201-207.

Flathman, P.E., and J.A. Caplan. April 1985. Biological Cleanup of Chemical Spills. Paper presented at Hazmacon '85 Conference, Oakland, CA.

Nyer, E.K. 1985. Treatment Methods for Organic Contaminants: Biological Methods - In Situ Treatment. In Groundwater Treatment Technology. Van Nostrand Reinhold. pp: 10-108.

U.S. EPA. 1985. In Situ Treatment - Bioreclamation. In Remedial Action at Waste Disposal Sites. Revised, EPA/625/6/-85/006, U.S. EPA.

U.S. EPA. Sept./Nov. 1984. Review of In-Place Treatment Techniques for Contaminated Surface Soils. Vol. 1, Technical Evaluation, Vol. 2, Background Information for In Situ Treatment. EPA-540/2-84-003a, and EPA-540/284-003b, (NTIS PB-124881 and PB-124899), U.S. EPA.

Ward, C.H., and M.D. Lee. 1985. In Situ Technologies. In Groundwater Pollution Control. Canter and Knox, Eds., Lewis Publishers.

Wetzel, R.S., et al. August 1986. Field Demonstration of In Situ Biological Treatment of Contaminated Groundwater and Soils. EPA/600/9-86/022, U.S. EPA, pp. 146-160.

Yaniga, P.M., and W. Sanith. 1984. Aquifer Restoration via Accelerated In Situ Biodegradation of Organic Contaminants. In Proceedings, NWWA/API Conference on Petroleum Hydrocarbons and Organic Chemicals in Groundwater - Prevention, Detection, and Restoration. pp. 451-470.

PHYSICAL TREATMENT

Cheremisinoff, P.N., and F. Ellerbusch. 1980. Carbon Adsorption Handbook. Science Publishers, Ann Arbor, MI.

Cheremisinoff, N., and Azbel, D. 1983. Liquid Filtration. Science Publishers, Ann Arbor, MI.

Dobbs, R.A., and J.M. Cohen. April, 1980. Carbon Adsorption Isotherms for Toxic Organics. EPA-600/8-80-023, U.S. EPA.

Gosset, J.M., et al. June 1985. Mass Transfer Coefficients and Henry's Constants for Packed-Tower Air Stripping of Volatile Organics: Measurement and Correlation. ESL-TR-85-18, Final Report, U.S. Air Force.

Kavanaugh, M.C., and R.R. Trussel. Dec. 1980. Design of Aeration Towers to Strip Volatile Contaminants from Drinking Water. Journal AWWA.

Modern Pollution Control Technology, Vol. 2, Water Pollution Control. Research and Education Association, 1978.

Perry and Chilton, Chemical Engineers' Handbook. 5th Ed., 1973, McGraw Hill, NY.

Schweitzer, P.A. 1979. Handbook of Separation Techniques for Chemical Engineers. McGraw Hill, NY.

Shukla, Harish M., and Hicks, R.E. Process Design Manual for Stripping of Organics. EPA/600-/2-84-130, U.S. EPA.

Treybal, R. 1983. Mass Transfer Operations. 3rd Ed. McGraw-Hill, NY.

SOLIDS DEWATERING

Metcalf and Eddy, Inc. 1972. Wastewater Engineering: Collection, Treatment, Disposal. McGraw-Hill, NY.

Perry and Chilton, Chemical Engineers' Handbook. 5th Ed., 1973, McGraw-Hill, NY.

Research and Education Association. 1978. Modern Pollution Control Technology Vol. II, Solid Waste Disposal. Research and Education Association.

SOLIDS PROCESSING

Given, I.A. 1973. Mining Engineering Handbook. Society of Mining Engineers, NY.

Taggert, A.F. 1951. Elements of Ore Dressing. John Wiley, NY.

SOLIDIFICATION, FIXATION, AND STABILIZATION

Technical Handbook for Stabilization/Solidification Alternatives for Remedial Action at Uncontrolled Hazardous Waste Sites. Environmental Laboratory, U.S. Army Engineers Waterways Experiment Station, Vicksburg, MS.

U.S. EPA. Sept. 1982. Guide to the Disposal of Chemically Stabilized and Solidified Waste. EPA Doc. No. SW-872. Municipal Environmental Research Laboratory, U.S. EPA, Cincinnati, OH.

U.S. EPA. June 1982. Remedial Action at Waste Disposal Sites. Municipal Environmental Research Laboratory, U.S. EPA, Cincinnati, OH.

THERMAL TREATMENT

Ahling, B. Nov. 1979. Destruction of Chlorinated Hydrocarbons in a Cement Kiln Environmental Science and Technology. Vol. 13, No. 11.

Brunner, C.R. 1984. Incineration Systems Selection and Design. Van Nostrand Reinhold, NY.

Environment Canada, Environmental Protection Service, Environmental Impact Control Directorate, Waste Management Branch. 1982. Destruction Technologies for Polychlorinated Biphenyls (PCBs). Based on a report to the Waste Management Branch by M.M. Dillon Ltd., Consulting Engineers and Planners, Toronto, Ontario, Canada.

Frankel, I., Sanders, N., and Vogel, G. 1983. Survey of the Incineration Manufacturing Industry. CEP, March 1983.

Journal of the Air Pollution Control Association. July 1982, Vol. 32, No. 7.

Lauber, J.D. 1982. Burning Chemical Wastes as Fuels in Cement Kilns. Journal of the Air Pollution Control Association, July 1982, Vol. 32, No. 7.

McBride, J.L., and Heimback, J.A. Skid Mounted System Gives California Hazardous Wastes Hot Time. Pollution Engineering, July 1982.

McCarthy, J.J. Feb. 1982. Technology Assessment of the Vertical Well Chemical Reactor. EPA-600/2-82-005, Prepared for U.S. EPA, Municipal Environmental Research Laboratory, Office of Research and Development.

Oberacker, D.A. 1984. Hazardous Waste Incineration Performance Evaluations by the United States Environmental Protection Agency. EPA-600/D-84-285. Prepared for U.S. EPA, Cincinnati, OH.

Peters, J.A., T.W. Hughes, and R.E. Mourninghan. 1983. Evaluation of Hazardous Waste Incineration in a Cement Kiln at San Juan Cement. Monsanto Research Co., Dayton, OH.

Seebold, J. A. Practical Flare Design. Chemical Engineering, December 10, 1984.

U.S. Congress, Office of Technology Assessment, Industry, Technology, and Employment Program. 1985. Superfund Strategy--Preventing a Toxic Tomorrow.

U.S. EPA. Sept. 1981. Engineering Handbook for Hazardous Waste Incineration. NTIS Report No. P881-248163, Prepared for U.S. EPA by Monsanto Research Corp., Dayton, OH.

Weltzman, L. 1983. Cement Kilns as Hazardous Waste Incinerators. Environmental Progress, Feb. 1983, Vol. 2, No. 1.

Wilhelmi, A.R., and Knopp, P.V. Wet Air Oxidation--An Alternative to Incineration. CEP, Aug. 1979.

Williams, I.M., Jr. 1982. Pyrolytic Incineration Destroys Toxic Wastes Recovers Energy. Pollution Engineering, July 1982.

Zanetti, W.J. Plasma: Warming Up to New CPI Applications. Chemical Engineering, December 1983.

III - REMOVAL/COLLECTION TECHNOLOGIES

CLEAN/REPLACE CONTAMINATED WATER AND SEWER LINES

Cleaning Pipelines: A Pigging Primer. Chemical Engineering, Feb. 4, 1985.

U.S. EPA. Oct. 1983. Demonstration of Sewer Relining by the Insituform Process, Northbrook, IL. EPA-600/2-83-064.

WPCF. 1980. Operation and Maintenance of Wastewater Collection Systems. Manual of Practice No. 7, WPCF.

DRUM AND DEBRIS REMOVAL

U.S. EPA. June 1982. Handbook - Remedial Action at Waste Disposal Sites. EPA-625-6-6-82-006, Cincinnati, OH.

ENHANCED REMOVAL

Donaldson, E.C., G.U. Chilingarian, and T.F. Ven. 1985. Enhanced Oil Recovery. Fundamentals and Analyses, 1, Elsevier Science Publishers B.V., Amsterdam, The Netherlands.

H.K. Van Poollen and Assoc., Inc. 1980. Enhanced Oil Recovery. Pennwells Publishing Company, Tulsa, OK.

Koltuniak, D.L. In Situ Air Stripping Cleans Contaminated Soils. Chemical Engineering, August 18, 1986, pp. 30-31.

Patton, C.C. 1981. Oilfield Water Systems, Norman, Oklahoma. Campbell Petroleum Series.

Schumacher, M.M., Ed. 1980. Enhanced Recovery of Residual and Heavy Oils. Noyes Data Corp., Park Ridge, NJ. (Contains references.)

EXCAVATION

Peurifoy, R.L. 1970. Construction Planning, Equipment and Methods. 2nd Ed., McGraw-Hill, NY. (Somewhat dated but a good overview of solids handling equipment.)

GAS COLLECTION

Argonne National Laboratory. Feb. 1982. Environmental Impacts of Sanitary Landfills and Associated Gas Recovery Systems. (ANL/CNSV-27), Argonne National Laboratory, Argonne, IL.

Emcon Associates. 1980. Methane Generation and Recovery From Landfills. Science Publishers, Ann Arbor, MI.

Landfill Methane Recovery. 1983. Energy Technology Review #80. Noyes Data Corp.

Tchobanoglous, Theisen, and Eliassen. 1977. Solid Wastes - Engineering Principals and Management Issues. McGraw-Hill, NY.

GROUNDWATER COLLECTION/PUMPING

Bureau of Reclamation. 1978. Drainage Manual. U.S. GPO, Washington, DC, 286 pp.

Bureau of Reclamation. 1981. Groundwater Manual. 2nd Ed., U.S. GPO, Washington, DC, 480 pp.

Freeze, et al. 1979. Groundwater. Prentice-Hall Inc., Englewood Cliffs, NJ.

Johnson Division, UOP, Inc. 1975. Groundwater and Wells. Johnson Division, UOP, Inc., Saint Paul, MN.

U.S. Army. 1971. Dewatering: Groundwater Control for Deep Excavations. Technical Manual No. 5-818-5, Prepared by the Army Engineers Waterways Experiment Station.

U.S. Department of Agriculture. 1971. Section 16, Drainage of Agricultural Land. In SCS National Engineering Handbook. Engineering Division Soil Conservation Service, Washington, DC.

U.S. EPA. June 1982. Handbook for Remedial Action at Waste Disposal Facilities. EPA-625/6-820-006, Prepared by Municipal Environmental Research Laboratory, Cincinnati, OH.

U.S. EPA. RCRA Groundwater Monitoring Technical Enforcement Guidance Document (TEGD).

IV - DISPOSAL TECHNOLOGIES

ATMOSPHERIC DISCHARGE

GCA Corp. Dec. 1984. Evaluation and Selection of Models for Estimating Air Emissions from Hazardous Waste Treatment, Storage and Disposal Facilities. EPS-450/3-84-020.

Kohl, A., and F. Riesenfeld. 1979. Gas Purification, 3rd Ed. Gulf Publishing Co.

Vogel, G. May 1985. Air Emission Control at Hazardous Waste Management Facilities. Journal of the Air Pollution Control Association, May 1985.

Florida Department of Environmental Regulation. April 1981. Class V Injection Well Inventory.

U.S. EPA. Dec. 1977. An Introduction to the Technology of Subsurface Wastewater Injection. EPA-600/2-77-240. Prepared for the U.S. EPA by Don L. Warner, University of Missouri-Rolla and Jay H. Lehr, National Water Well Association.

U.S. EPA. Sept. 1982. Fate of Priority Pollutants in Publicly Owned Treatment Works. Volumes I and II, EPA 440/1-82/303, U.S. EPA, Water and Waste Management Series, Effluent Guidelines Division WH-522.

U.S. EPA. July 1980. Treatability Manual, Volume Treatability Data. EPA 600 8-80-042a, U.S. EPA Research and Development Series.

Versar, Inc. Dec. 1979. Water-Related Environmental Fate of 129 Priority Pollutants. Volumes I and II, NTIS PB80-204381, Versar, Inc., Springfield, VA. Prepared for U.S. EPA, Washington, DC.

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APPENDIX D
DOCUMENTATION OF ARARs

The accompanying table presents a suggested format for summarizing the identification and documentation of ARARs in the RI/FS process. This format assumes that two previous ARARs identification steps have taken place during the RI/FS. First, it assumes that a list of Federal and State ARARs has been developed through consultations between the lead and support agencies. This list should include chemical-, action-, and location-specific requirements and, in the case of multiple ARARs (e.g., both a Federal and State chemical-specific ARAR), the ARAR to be used for the site in question should be specified. Second, it assumes that identified requirements and the reasons for their applicability or relevance and appropriateness have been integrated into the narrative descriptions of each alternative as part of the "Detailed Analysis" chapter in the FS report. Therefore, this appendix serves as a summary of the ARARs for each alternative, whether the alternative will meet its ARARs, and if not, what type of waiver would be required.

The suggested format for the documentation of ARARs is presented here in the form of an example. The example is meant to be generic and conceptually simplistic, while demonstrating the different types of documentation that may be required.

The site consists of an inactive landfill. TCE, benzene, and cadmium contamination have been found in the soils, ground water, and a stream adjacent to the landfill at the following levels:

	Soils	GW	Surface Water
TCE	1-100 ppm	1-100 ppb	1-10 ppb
Benzene	1-100 ppm	1-100 ppb	1-10 ppb
Cadmium	1-500 ppm	1-100 ppb	1-5 ppb

The alternatives considered are:

- **Alternative 1--No action**
- **Alternative 2--Excavation and offsite disposal in an approved RCRA landfill**
- **Alternative 3--Excavation and onsite disposal in an approved RCRA landfill**
- **Alternative 4--Excavation and onsite incineration of waste and contaminated soil**

In addition, Alternatives 2, 3, and 4 include the extraction and treatment of ground water. Treatment will consist of precipitation and air stripping.

As documented in the table, the Federal MCL of 5 ppb will be achieved by air stripping prior to reinjection into the ground water for TCE and benzene for each alternative. Similarly, the federal MCL of 10 ppb for cadmium will be achieved by the precipitation treatment. The State ground-water standard of 5 ppb will not be met, however, for any of the alternatives. Because of the characteristics of the ground water, this level cannot be met using available technologies; therefore, a technical infeasibility waiver is anticipated. In addition, none of the action alternatives will directly address the surface water; consequently, a waiver may also be required.

Each of the action- and location-specific alternatives are listed and compliance is documented under the alternatives for which they apply. Both State and Federal requirements are listed, and the component of the alternative that the requirement addresses is documented.

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